SPECTRAL STUDIES OF IONIZED IODINE ATOMS: I III - I VI

ABSTRACT

THESIS

SUBMITTED FOR THE AWARD OF THE DEGREE OF

Doctor of Philosophy

IN

PHYSICS

BY

ANJUM NAZ

Under the Supervision of

Dr. Tauheed Ahmad

(READER)

DEPARTMENT OF PHYSICS
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

2008

ABSTRACT

In the thesis entitled "SPECTRAL STUDIES OF IONIZED IODINE ATOMS: I III – I VI", four different spectra of iodine have been studied at length. The whole thesis comprises of six chapters and one appendix.

The first chapter describes the theoretical aspect of Atomic Spectra and various methods of different approximations used to calculate the structure of complex atoms/ions, specially Hasrtree-Fock method, central field approximations, self-consistent-field method, Cowan's approach and a brief description of Cowan's code computer programs. Handling of isoelectronic sequences in atomic spectra and Edlén's polarization formula for calculating the ionization potential of different ions have also been described in this chapter.

The second chapter deals with the experimental part of the project. Light sources, the spectrograph and experimental set up, recording the iodine spectra, its measurement and calibration into wavelengths is explained. Special attention is paid to the treatment of the variation of spectral line intensities and their use in separating out the various ionization stages that contribute simultaneously to the recorded spectra. The described principles are vividly illustrated.

The third chapter is devoted to describe the spectrum of doubly ionized iodine atoms (I III). In this ion, transitions from ground configuration $5s^25p^3$ to $5s5p^4$, $5p^25d$, $5p^26d$, $5p^27d$, $5p^26s$, $5p^27s$ and $5p^28s$ configurations have been investigated. Multi-configuration interaction Hartree-Fock and least squares fitted parametric calculations have been used to interpret the observed spectrum. **One hundred fifteen** levels have

been established based on the identification of **three hundred seven** spectral lines. Entire work is published in Physica scripta.

Trebly ionized spectrum of iodine (I IV) has been presented in **fourth chapter**. This spectrum has been extended extensively to include $5s^25p^2$, 5p5d, 5p6d, 5p7d, 5p6s, 5p7s and 5p8s configurations and all these results have already been published in Physica scripta. Doubly exited configurations namely 5p7p, 5p5f, $5p^4$, $5s5p^25d$, $5s5p^26s$, $5d^2$, $6s^2$, 5d6s and 6s6d have been studied for the first time. Strong configuration interaction between the even parity systems has been observed. The configuration 5p6p and 5p4f are expected to give strong transitions to 5p5d and 5p6s configurations but they could not be studied as these transitions lie only partially in our region of present investigation. However, their calculated values have been included in the Table 4.3. **Thirty** levels of odd parity and **one hundred fourteen** levels of even parity configurations have been observed experimentally and **four hundred thirty four** spectral lines have been identified in I IV spectrum.

The fifth chapter explains the structure of four-time ionized iodine (I V). This ion has partially one electron system and partially three-electron system that arises due to the core excitation. In one electron part the analysis is extended to include $5s^25p$, 6p, 7p, 8p, 6s, 7s, 8s, 9s, 5d, 6d, 7d, 4f, 5f, 6f, 5g and 6g configurations. While three-electron system covers $5s5p^2$, $5p^3$, 5s5p5d, 5s5p6s, $5p^25d$ and $5p^26s$ configurations. **One hundred six** level have been established out of which **fifty three** levels are new. A total of **three hundred fifteen** spectral lines have now been classified in I V . The ionization potential of I V is calculated to be 415510 ± 300 cm^{-1} or 51.52 ± 0.04 eV.

The sixth chapter deals with the spectrum of five-time ionized iodine (I VI). This is Cd I like ion with $5s^2$ as ground configuration. The published results on this ion so for covers the configurations $5s^2$, 5s5p, $5p^2$, 5s5d, 5s6s, 5s6p, 5p5d, 5p6s, 5p7s and two levels of $4d^9 5s^2 5p$ and one level of $4d^9 5s^2 4f$. The present work extends the existing analysis to include new configurations 5s7p, 5s4f, 5s5f, 5p6d, 5s8s, 5s6d, 5s5g, 5s6g, 5s7g, $5d^2$, $6s^2$, 5p6p, 5p4f, $4d^9 5s^2 5d$ and $4d^9 5s^2 6s$. **One hundred twenty nine** experimental energy levels have been found based on the identifications of **two hundred sixty five** spectral lines. The ionization potential of I VI was found to be 600010 ± 1000 cm^{-1} or 74.39 ± 0.12eV.

The appendix I contains the sample spectrograms of iodine used in thee present work with prominent lines of Oxygen, Aluminum, Carbon and Iodine III, IV, V & VI marked on it.

In summary **72** configurations belonging to I III – I VI have been studied experimentally to establish **524** energy levels out of which **356** are new. Beside experimentally observed levels, **290** energy levels have been predicted theoretically as well. In the process **1321** spectral lines have been identified covering the wavelength region 139 –1853Å.

SPECTRAL STUDIES OF IONIZED IODINE ATOMS: I III - I VI

THESIS

SUBMITTED FOR THE AWARD OF THE DEGREE OF

Doctor of Philosophy

IN

PHYSICS

BY

ANJUM NAZ

Under the Supervision of

Dr. Tauheed Ahmad

(READER)

DEPARTMENT OF PHYSICS

ALIGARH MUSLIM UNIVERSITY

ALIGARH (INDIA)

2008

Dedicated to a Drop of Ocean of Affection of my Parents

DEPARTMENT OF PHYSICS
ALIGARH MUSLIM UNIVERSITY
ALIGARH - 202002 (INDIA)

PH. : 91-571-2700984
PH. & FAX : 91-571-2701001

CERTIFICATE

I certify that Miss Anjum Naz has carried out the analyses of Iodine spectra; I III – I VI under my supervision and that she has performed the work mainly herself. The work is original and I permit her to submit the thesis entitled "Spectral Studies of Ionized Iodine Atoms: I III – I IV" for the award of Ph.D. degree of the Aligarh Muslim University.

Dr. Tauheed Ahmad

Reader

Dated: March 20, 2008

Acknowledgment

First and foremost, I sincerely offer my endless thanks to **Allah**, the **Almighty**, the **most merciful** and the **most beneficent**, whose gracious blessing gave me, required devotion for the completion of this work.

I am fortunate to have worked under the supervision of **Dr. Tauheed Ahmad** Reader, Department of Physics AMU, Aligarh. He has been very kind and always helpful throughout this work. I am indebted for his assiduous guidance, encouragement and academic help. His pertinent ability to probe into the research problem has made this study a pleasant one.

I must acknowledge the generous laboratory support of **Prof. Y.N. Joshi** of St. Francis Xavier University, Antigonish (Canada). Most of the spectra used in this work have been recorded in his lab. After all nothing could have been possible without rigorous use of Cowan code programs. **Dr. R. D. Cowan's** generosity in providing his code is gratefully acknowledged.

It gives me immense pleasure to express my deep sense of gratitude and sincere thanks to **Prof. Mohd. Zafar**, Chairman, Department of Physics AMU, Aligarh for providing the required facilities for this work.

Special thanks are due to my respected teacher **Prof. Muhammad Irfan**, former Chairman, Department of Physics AMU, Aligarh for his *benign guidance, inspiration and encouragement at every stages during the period of my research work.*

I am also indebted to my respected teachers ***Prof. Rahimullah Khan, Dr. Shabbir Ahmad*** *and* ***Dr. S.M. Afzal*** *for their kindness, help and useful discussions. I would also like to thank* ***Dr. (Mrs.) S. Jabeen*** *for her cooperation and help.*

I will fail in my duty if I do not pay my sincere gratitude to my parents for their constant inspiration and encouragement. My special thanks are due to my sister ***Tabassum*** *for her help in preparing the tables and figures. I must not forget to acknowledge the moral support and willing cooperation of my brothers* ***Rashid*** *and* ***Haroon*** *and sister* ***Tarannum.***

ANaz

Anjum Naz

CONTENTS

	Page No.
Introduction	1
CHAPTER – 1 THEORETICAL APPROACH	
1.1 Introduction	4
1.2 Hartee's Self-consistent-field method	5
1.3 Hartee's atomic wave function	6
1.4 Hartee-Fock atomic wave function	7
1.5 Numerical Procedure	10
1.6 Cowan's approach	10
1.7 Isoelectronic Sequence	14
1.8 Edlén's polarization formula for ionization potential	16
References	20
CHAPTER – 2 EXPERIMENTAL DETAILS	
2.1 Light sources	21
2.2 Trigger Module TM – 11A	22
2.3 Sliding Spark Source	24
2.4 The Spectrograph	24
2.5 Recordings of Iodine Spectra	26
2.6 Measurements and calibration of wavelength	27
2.7 Ionization discrimination	30
References	31
CHAPTER – 3 THE THIRD SPECTRUM OF IODINE: I III	
3.1 Introduction	32
3.2 The term structure of I III	33

3.4 Ionization potential 37
References 39
Tables 41
CHAPTER – 4 THE FOURTH SPECTRUM OF IODINE: I IV
4.1 Introduction 60
4.2 The term structure 60
4.3 Results and discussion 62
4.4 Ionization potential 66
References 67
Tables 68
CHAPTER – 5 THE FIFTH STRUCTURE OF IODINE: I V
5.1 Introduction 100
5.2 The term structure of I V 100
5.3 Results and discussion 101
5.4 Ionization potential 104
References 105
Tables 106
CHAPTER – 6 THE SIXTH SPECTRUM OF IODINE: I VI
6.1 Introduction 131
6.2 The term structure of I VI 132
6.3 Analysis and discussion 132
6.4 Ionization potential 135
References 136
Tables 137
Appendix I SAMPLE SPECTRA OF IODINE 162
List of publications 165

Introduction

Spectra are the best tools to study the atomic properties. Numerous properties of the elements have been discovered through the study of the radiation they emit. The emitted radiations are the characteristic spectra of the elements. The study of these spectra is carried out through spectroscopic techniques. Atomic spectral studies are of paramount importance in another way also. If we want to build ion lasers satisfying all requirements of physics industry, we must know with great precision the level structure and transition probabilities of all usable ions. The more extensive and precise knowledge of these details shall be, the better we shall be able to study the lasing actions. This increases the importance of completing our knowledge of the structure of atomic ions in every respect. The analysis of atomic spectra has an old history, and energy structure of the neutral and singly ionized atom is supposed to be well known in most of the cases. The importance of the spectral studies of heavier atomic ions has tremendously increased because of demands from astrophysics, plasma and laser science.

The spectra of various refractory metals are important for developing new energy sources especially by means of tokamak and other controlled fusion devices. In this regard a workshop on "Challenges in Plasma Spectroscopy for Fusion Research Machines" organized by International Atomic Energy Agency (IAEA) very recently (February 20 - 22, 2008) at Birla Auditorium, Jaipur, India. A lot of emphasis was given on the accurate spectroscopic data for the planned International Tokamak Experimental Reactor (ITER) for fusion studies.

It is worthless to mention the importance of any particular element of the periodic table in the era of fast growing technology and its medical and industrial application. Spectroscopic data are of great help in optical hole burning, used to enhance the memory for data storage capacity. On the other hand industries involved in lithography are using spectroscopic data very successfully. Our laboratory has been engaged in providing data at National and International level since last four decades. More than thirty different elements have been studied so far. Fifteen Ph.D. theses have been completed on various elements that includes Y, Zr, Mo, Nb, Ta, Sb, Te, Cs, I etc. I have chosen to study the four different spectra of Iodine viz. I III, I IV, I V and I VI in the vacuum ultraviolet wavelength region and would like to shed some light on its basic properties.

It has been discovered by Courtois in 1811. It is bluish-black lustrous solid, volatilizing at ordinary temperatures into a blue violet gas with an irritating odor. Its atomic weight is 126.9045 (based upon C-12); atomic no. 53; b.p.184.35°C; m. p. 113°C ; and density of gas 11.27 g /l ; sp. gr for solid is 4.93 (at 20°C), it has twenty three isotopes, only one stable isotope I^{127} is found in nature. It occurs sparingly in form of iodides in sea water from which it is assimilated by seaweeds. Iodine exhibits some metal like properties. It dissolves readily in chloroform, carbon tetrachloride or carbon disulfide to form beautiful purple solutions. It is only slightly soluble in water. The artificial radioisotope I^{131}, with half life of 8 days, has been used in treating the thyroid gland. Lack of iodine is the cause of goiter the iodides and thyroxin which contains iodine, are used internally in medicine, and a solution of KI and iodine in alcohol is used for external wounds. Potassium iodide finds use in photography.

In earlier days lot of simple spectra like one electron and two electron systems were studied mainly through isoelectronic extrapolations or predictions made by simple calculations. However, the complex atomic systems either could not be studied or found to be erroneous later on and were being revised. In recent past, fast computers capable of handling large data became available and a handful of computer codes that can calculate the structure of complex ions very reliably, the renewed interest of studying complex spectra has risen up. Our laboratory is especially engaged in the study of complex systems. The spectra of iodine ions which I have studied are in fact very complex, making three or four electron systems. We have tried to investigate some of them. The basic procedure and technicalities involved will be discussed at length in the following chapters.

In the first chapter, the basic theory of Atomic Structure and Spectra has been described. Second chapter provides all the experimental details. The remaining four chapters (Ch III – VI) are devoted to describe the detailed energy structure of I III, I IV, I V and I VI respectively. An appendix in the end illustrates the iodine spectrograms used in this work.

CHAPTER - 1

Theoretical Approach

1.1. Introduction

The first decade of the twentieth century was important as showing, through the work of Planck on black body radiation and Einstein on the photo electric effect, that there is much more to the laws of interaction of matter and radiation than is given by the nineteenth century electromagnetic theory. These developments mark the birth of quantum theory. Bohr's first work on atomic structure gave a theory of spectrum of hydrogen, which involved several important advances. The quantum mechanical treatment by Schrodinger's wave equation gave a much better explanation to the existing theory of atomic structure.

Atomic structure calculations involve basically the solution of Schrodinger's equation. The solution of this equation for many body system is very complicated and even for two electron system like He, an exact solution does not exist, and to make the solution feasible some approximations have to be applied. Fortunately certain approximations are known to provide good qualitative and quantitative agreement with observations [1] and [2]. The most commonly used approximation is **central field approximation.** The central field approximation was worked out during 1920's starting with Bohr's first proposal in 1922, supplemented by the discovery of electron spin and of exclusion principle by Pauli in 1925 and completed with the Hartree's proposal of method of self consistent field in 1928 and with the so called Hartree-Fock method in 1930.

In Hartree method Schrondinger's equation is solved by taking a many body Hamiltonian operator and atomic function, which is the product of all the functions belonging to individual electrons of the atom. In taking such an approximate simplified function, the fact that an electron possesses spin angular momentum and that it obeys Pauli's exclusion principle inside an atom is neglected. In Hartree-Fock method these facts are taken into account the atomic wave function in this case is of determinantal form consisting an individual one electron wave function as elements. Such a wave function then satisfies the two above mentioned requirements too.

Central field approximation is one in which the electrons to the first approximation, are regarded to be moving independently in a field that arises as net result of positive charge of nucleus and average distribution of negative charges of electrons in the orbit. According to this approximation, various electrons are grouped together in an atom according to their quantum numbers n and ℓ irrespective of mutual orientations of electron orbit and spins, hence one electron wave functions are taken with the same radial functions to represent all wave functions of any one (n ℓ) group. This approximation has been found good enough to explain the spectra of alkali metals in fair detail and satisfactory to provide size and energies of general atoms to a good approximation.

1.2. Hartree's Self-consistent-field method:

In Hartree's self-consistent-field method [1] it is assumed that each electron moves in an average potential arising from nuclear charge and from other electrons. Schrodinger equation for an electron moving in that potential is solved. The wave function of the desired quantum number in that potential is chosen and assumed that this wave function is to be used in finding charge density due to all electrons being considered. Total charge density due to all electrons being considered is built up, and hence potential arising from this charge density is found out. Then the requirement of self-consistency is sought out so that this potential must be consistent with the initial one assumed in setting up the Schrodinger equation.

Hartree found that he could set up a manageable procedure for determining this self-consistent field, based on the method of iteration or successive approximations. He proceeded in the following way. He determined charge densities and potentials from these functions. Then solving Schrodinger's equation, he found out the final wave function. If these final and initial functions agreed within the limit of tolerance the trial function were regarded to be correct used for determining other atomic properties, otherwise a new cycle of the same process but with some better guessed function started. This process continued until the self-consistency between trial and final wave functions were achieved. Hartree [3] by his experience, found that the most convenient and fruitful operation was that in which a new cycle of operation was started by using the final function of its previous cycle as initial function of this cycle. Some time an average of the initial and final function of preceding cycle or linear combination of the two was fed as initial function to the next starting cycle. It was found after a number of cycles the process converged and thus to a good approximation the so called self consistent function were obtained.

1.3. Hartrre's atomic wave function:

According to central field model as discussed earlier the wave function of a N- electron atom will be a function which contains the complete contribution from all N wave functions belonging to the individual electrons. Now the problem is how to construct such a function in which the contributions from all the one electron wave function are incorporated. Such a wave function ϕ to Hartree [4] is a product of all the one electron wave function Ψs viz.

$$\phi = \psi_1(1)\psi_2(2)\ldots\ldots\ldots\ \ldots\psi_N(N) \text{ ---------------(1)}$$

1.4. Hartree-Fock atomic wave function:

Hartree's atomic wave function in the product form given by equation (1) does not conform to Pauli's exclusion principle. The simple function which satisfied this principle is a determinantal function. Such an approximate N-electron wave function ϕ, in the form of determinant of one electron wave function may be given as below:

$$\phi = (N!)^{-1/2} \begin{vmatrix} \psi_\alpha(1) & \psi_\alpha(2) & \cdot\ \cdot\ \cdot\ \cdot\ \cdot & \psi_\alpha(N) \\ \psi_\beta(1) & \psi_\beta(2) & \cdot\ \cdot\ \cdot\ \cdot\ \cdot & \psi_\beta(N) \\ \cdot & \cdot & \cdot\ \cdot\ \cdot\ \cdot\ \cdot & \cdot \\ \cdot & \cdot & \cdot\ \cdot\ \cdot\ \cdot\ \cdot & \cdot \\ \psi_\pi(1) & \psi_\pi(2) & \cdot\ \cdot\ \cdot\ \cdot\ \cdot & \psi_\pi(N) \end{vmatrix} \text{ ---------------- (2)}$$

For central field type atom the single electron wave function is taken of the form

$$\psi_\alpha(j) = \frac{1}{r_j} P(n_\alpha l_\alpha, r_j) S(l_\alpha m_\alpha \theta_j, \phi_j) \chi_j(s_j) \text{ ---(3)}$$

where P, S and χ are radial wave function, spherical harmonic and spin wave function respectively,(n_α, ℓ_α, m_α) are the quantum numbers of the wave function α and (r_j , θ_j , φ_j and s_j) are the radial , spherical, polar and spin coordinates of electron j.

The difference between Hartree and Hartree Fock method is only that in former we are using the function (1) while in latter the function (2), other treatment being exactly the same. Of course in the final expression of Hartree Fock method we are getting some extra term as well. The presence of these terms greatly complicates the resulting set of integro-diffrential equations. Scientists therefore attempted to modify it, to make simple and physically more comprehensible. Slater's life long work is most important in this respect. It has been developed and described by Condon and Shortley [5] also. The recent book of C. F. Fischer [6] is valuable addition to the subject.

The Hartree-Fock method gives accurate result for light atoms, but a relativistic correction is necessary for heavy ones. The integro-differential equations involved in Hartree-Fock method are divided into smaller manageable integrals known as "**Slater Parameters**"(E_{av}, F^k, G^k, ζ_{nl}, and R^k) The E_{av} represents the average energy or the centre of gravity of the configuration . The integral F^k, G^k, ζ_{nl} give the term structure of a single configuration. The intra-configuration interaction can be introduced through R^k integrals.

$\mathbf{F^k}$($n\ell$, n' ℓ') represents that part of the electrostatic energy which depends on orientation of ℓ vectors and is responsible for the separation of terms with different L values in LS coupling . $\mathbf{G^k}$ (nℓ, n' ℓ') give energy due to exchange forces which depend on the spin orientations. They cause splitting terms with equal L but different total spin S. In case of equivalent electron like p^2, p^3 etc, $\mathbf{G^k}$ parameters vanish. ζ_{nl} represents spin orbit interaction energy, the magnetic spin orbit interaction may be introduced as perturbation and give the fine structure splitting. The shape of various Slater integrals can be seen in the following expressions.

$$E_{av} = \int_0^{\infty} \left[r^{2l+2} \frac{d}{dr}\left(\frac{R^*_{nl}}{r^l}\right)\frac{d}{dr}\left(\frac{R_{nl}}{r^l}\right) - 2ZrR^*_{nl}R_{nl} \right] dr$$

$$F^k = \int_0^{\infty}\int_0^{\infty} R^*_{n_i l_i}(r_1)R^*_{n_j l_j}(r_2)R_{n_i l_i}(r_1)R_{n_j l_j}(r_2) \times \frac{2r(a)^k}{r(b)^{k+1}} r_1^2 r_2^2 dr_1 dr_2$$

$$G^k = \int_0^{\infty}\int_0^{\infty} R^*_{n_i l_i}(r_1)R^*_{n_j l_j}(r_2)R_{n_j l_j}(r_1)R_{n_i l_i}(r_2) \times \frac{2r(a)^k}{r(b)^{k+1}} r_1^2 r_2^2 dr_1 dr_2$$

$$R^k = \int_0^{\infty}\int_0^{\infty} R^*_{n_i l_i}(r_1)R^*_{n_j l_j}(r_2)R_{n_r l_r}(r_1)R_{n_t l_t}(r_2) \times \frac{2r(a)^k}{r(b)^{k+1}} r_1^2 r_2^2 dr_1 dr_2$$

$$\zeta_{nl} = h^2 \int_0^{\infty} |R_{nl}|^2 \zeta(r) r^2 dr = \frac{e^2 h^2 Z^4}{2m^2c^2a_0^3 n_i^3 l_i(l_i + 1/2)(l_i + 1)}$$

1.5. Numerical Procedure:

Numerical procedure for solving Hartee-Fock equation have been described by many authors, Hartee [4, 7] himself was the first to give a detailed account of the numerical procedures for the solutions of equation without exchange. Later on these procedure were extended and applied for the equations with exchange terms. Based on these procedures and with some modifications much works were carried on for quite some time. A survey of such atomic structure calculations has been compiled and published by Hartree [8]. However, the availability of fast computers and a variety of computer codes in recent years made it possible to calculate the structure of any ion in the periodic table. I have frequently used the Cowan's code programs for *ab initio* and least squares fitted parametric calculations. I would like to shed some light on R.D. Cowan's code.

1.6. Cowan's approach:

Cowan's approach was essentially to solve the Slater parameters ($E_{av,}$ F^k, G^k, ζ_{nl}, and R^k) based on the theory outlined in the preceding sections. He employed self-consistence field method for the calculation of atomic radial wave functions and of various radial integrals involved in the calculation of atomic energy levels and spectra. The Cowan's code consists of four different programs in the sequence RCN, RCN2, RCG and RCE.

(i) RCN:

This gives the starting part of any *ab initio* calculation all the basic input information like name of the element, its atomic number, ionization stage and orbital information etc. is always provided to the input file called "IN 36". Each program automatically provides input information to the succeeding program. A typical example of the input file prepared to calculate the structure of I IV for both the parities is given in Table 1.1.

The program RCN calculates single configuration radial wave function $P_{nl}(r)$ for spherically symmetrized atom by using any of the following homogeneous differential approximation to Hartree- Fock method among the possible options Hartree (H), Hartree-Fock Slater (HFS), Hartree plus Statistical Exchange (HX), Hartree Slater (HS) and Hartree-Fock (HF). Frequently used methods are HX or HF.

Apart from calculating $P_{nl}(r)$ it also calculates the various radial integrals R^k, F^k, G^k, ζ_{nl} and E_{av} for each configurations involved with approximate relativistic and correlation energy corrections. Relativistic terms can be included in the potential function of the diffrential equation (HXR or HFR) to give approximate relativistic corrections in heavy atoms (important for outer orbital only if $Z > 50$ and for inner orbital if $Z > 20$). Similarly a correlation term can be included in order to make the potential function more negative, and thereby help to bind negative ion.

(ii) RCN2 :

The radial wave functions from the output of RCN becomes the input to RCN2 for the calculation of the various multiple configuration radial integrals, overlap integrals, configuration- interaction Coulomb integrals R^k and spin- orbit interaction integrals ζ_{nl} and radial electric dipole and electric quadruple integrals. It also calculates all the quantities required by the next program to calculate the energy levels and spectra of an atom/ion and prepares the input file for the next program RCG. R.D. Cowan himself in his book describes its further detail on the "Theory of Atomic Structure and Spectra" [9].

Table: 1.1 INPUT FILE FOR RCN PROGRAM TO RUN COWAN CODE

```
200-90 0 2  01.   0.2  5.E-08    1.E-11-2 00190 0 1.0   0.65   0.0 1.00 -6
   53     4I-3+  5p2             4D10 5S2  5P2
   53     4I-3+  sp2d            4D10 5S1  5P2  5D1
   53     4I-3+  sp2s            4D10 5S1  5P2  6S1
   53     4I-3+  5p4             4D10 5S0  5P4
   53     4I-3+  5p6p            4D10 5S2  5P1  6P1
   53     4I-3+  5p7p            4D10 5S2  5P1  7P1
   53     4I-3+  5p4f            4D10 4F1  5S2  5P1
   53     4I-3+  5p5f            4D10 5S2  5P1  5F1
   53     4I-3+  6s2             4D10 5S2  5P0  6S2
   53     4I-3+  5d2             4D10 5S2  5P0  5D2
   53     4I-3+  5d6s            4D10 5S2  5D1  6S1
   53     4I-3+  6s6d            4D10 5S2  6S1  6D1
   53     4I-3+  sp3             4D10 5S1  5P3
   53     4I-3+  5p5d            4D10 5S2  5P1  5D1
   53     4I-3+  5p6d            4D10 5S2  5P1  6D1
   53     4I-3+  5p7d            4D10 5S2  5P1  7D1
   53     4I-3+  5p6s            4D10 5S2  5P1  6S1
   53     4I-3+  5p7s            4D10 5S2  5P1  7S1
   53     4I-3+  5p8s            4D10 5S2  5P1  8S1
   -1
```

Note: The first line is a control card.

53 in the 1st column is atomic no. I in 2nd column represents name of the element and 4 the spectrum no. 3rd column represents configuration and 4th column represents electronic distribution.

(iii) RCG :

The angular factor of various matrix elements are computed by RCG program. It calculates the energy eigenvalues of each individual energy level, transition wavelength, its wavenumber and the transition probabilities of each transition involved in the system. It also has a provision to calculate the electric quadruple E2 as well as magnetic dipole M1 transitions. Beside that it calculates the LS percentage composition of the mixed levels when the system is complex. Finally the average purities of all the configurations of both parities in LS as well as in jj coupling scheme. It also calculates the lifetime of the excited states. In fact RCG provide the main output of the *ab intio* calculations. This program has also an option to run with the least squares fitted parameters.

(iv) RCE :

This is the last part of the Cowan's code program and is employed to obtain the real experimental energy parameters. When sufficient number of energy levels (more than 50%) are known, they are used for least squares fitted calculations. The energy parameters so obtained are then used to calculate the unknown levels. This prediction is much closer to the real value. Moreover these new fitted parameters are used in RCG program to recalculate wavelength, transition probabilities and corresponding LS composition more accurately. This helps a lot to find out the levels with single transition or those levels with only one expected observable transition.

1.7. Isoelectronic sequence:

The term isoelectronic it-self explains that the atoms or atomic ions involved contain the same number of extra nuclear electrons. For example if we consider Sb, Te^{+}, I^{2+}, Xe^{3+}, Cs^{4+}....having atomic numbers 51, 52, 53, 54, 55 ... respectively. The singly ionized Te, doubly ionized I, triply ionized Xe, and four times ionized Cs, all have the same number of extra nuclear electrons as neutral Sb. As a convention we write neutral Sb as Sb I, singly ionized Te as Te II, doubly ionized I as I III, triply ionized Xe as Xe IV and so on. The series Sb I , Te II, I III, Xe IV, Cs V,... etc is termed as isoelectronic sequence [10] and named as Sb I like sequence the number written after the symbol of the element give the net charge of the core i.e. Z-(N-1) where Z is the atomic number , n is the total number of extra nuclear electrons this number is denoted by ζ often called spectrum number, for example ζ=1 in above mentioned sequence denotes the spectrum of neutral Sb. Similarly ζ=2, 3, 4, ...stand for singly ionized, doubly ionized, triply ionized atoms i.e. second spectrum of Te, third spectrum of I, fourth spectrum of Xe etc.

Since the number of extra-nuclear charges is the same all along the sequence, they should naturally possess the same spectral structure. Consequently they show remarkable similarities among themselves, which are very useful in comparing the transitions and energy levels obtained by the analysis of new spectra.

For comparison along the sequence if we plot the term T_{nlj} Vs Z we find only approximate trends because T_{nlj} increases very rapidly with Z and the comparison fails to reveal even serious irregularities in the analysis. To over come this difficulty, Prof. Edlén [10] studied in a verity of ways the Z dependences on of the energy levels and other atomic regularities so as to get precise comparisons. The E_{nlj}/ζ plot against ζ replaces steep upward trends of E Vs ζ plots by downward slopes, already permitting the use of larger scales. Successful efforts have been made then to straighten these curves for higher members of the sequence by adding a suitable constant "c" to ζ so as to take the form $E/(\zeta+c)$. This constant "c" is naturally more effective at the beginning of the sequence than for the higher members. It may be guessed from the equation $E_1/(\zeta_1+c)=E_2/(\zeta_2+c)$ where E_1 the energy of lower member of sequence, while E_2 is the energy of same level of the higher member of the sequence. By this way it becomes possible to make the curve horizontal and smooth. Once a horizontal trend is obtained more and more sensitive scale may be chosen for desired precise comparison. This kind of representation is utilized generally for the ground configuration or the configurations having the same n value as ground.

When n of the configurations concerned is different from that of the ground, the above mentioned representation fails to give horizontal curves, $E/(\zeta+c)$ Vs Z then give rather an upward rising trends for higher members of the sequence. This upward slope is reduced by subtracting $\zeta\, T_H$ from $E/(\zeta+c)$, the hydrogenic term T_H is given as

$$T_H = R\zeta^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

or more precisely [10,p.126] as

$$T_H = \frac{R\zeta^2}{n^2}\left\{1 + \frac{\alpha^2\zeta^2}{n^2}\left(\frac{n}{l+\frac{1}{2}} - \frac{3}{4}\right)\right\} \qquad \text{-----------(4)}$$

where R is Rydberg constant n_1, n_2 are the principal quantum numbers of the ground and other shell involved in the configuration concerned respectively. α being the fine structure constant.

1.8. Edlén's Polarization formula for ionization potential:

Within the same spectrum separation between the lines and their intensities decrease more or less regularly towards the shorter wavelength causing convergence to a limit called ionization limit. Out of these the lines that are transition between a fixed lower level and the upper level having all quantum number same except running principal quantum number n constitute a Rydberg series.

If we denote by E the relative term value counted upwards from the ground term, and by E_l the value of the series limit on the same scale, the absolute term value is defined as

$$T = E_l - E \qquad \text{------------ (5)}$$

Hence ionization potential (I P) which is the precise difference between the "upper most" and the "lower most" level of the system may be related as

$$IP = E_l = T + E \qquad \text{------------ (6)}$$

Writing the term value empirically as

$$T = \frac{R\zeta^2}{n^{*2}} \qquad \text{------------ (7)}$$

where $n^* = n - \delta$ being called effective principal quantum number and δ the quantum defect. By rearranging the equation for term value it can be written in the form of Ritz formula as

$$\delta = a + bt \qquad \text{------------ (8)}$$

where t is the "reduce term" and given by the relation

$$t = (n^*)^{-2} = \frac{T}{R\zeta^2} \qquad \text{------------ (9)}$$

The equations (5) (8) and (9) can be used to determine the unknowns a, b and E_ℓ provided that the energy level value E_ℓ are accurately known for at least three members of Rydberg series corresponding to the known principal quantum numbers n_1, n_2 and n_3.

Since the equations are involved in E_ℓ, the direct solution is not possible. Re-iteration process is adopted to solve them, starting with an approximate value of E_ℓ, that can be guessed.

Explicitly nine equations are obtained in the form of three sets corresponding to above equations (5), (8) and (9). First using the guessed E_ℓ value, three corresponding term values T are obtained from equation (5). These values of T are used in equation (9) to obtain corresponding values of δ. Equation (8) provides the means to find a and b. By using third δ a better approximation for the term t or T can be obtained. This feeded to one of the equations (5) will provide a better approximation for E_ℓ, that will give a better value of T from other two equations of (5). Continuing this process, second improved value of E_ℓ is obtained and so on until the difference between the last two successively approximated values of E_ℓ is within the desired limit E_ℓ. Once the final value of the series limit E_ℓ is fixed the effective quantum number n^* and the quantum defect δ can be calculated more accurately. In order to achieve still better accuracy, higher the terms of the Ritz formula should be considered by writing

$$\delta = a + bt + ct^2 + dt^3 + \ldots\ldots \qquad \text{-------(10)}$$

But to start with one should proceed from the two parameter formula in steps to include the third and fourth term. It is seen in practice, that we can proceed to fourth term profitably in case of unperturbed s-series only, up to third term can be added to p-series and in some cases of d-series of heavy atoms. For the rest of the series a two term Ritz formula is sufficient.

Edlén observed in the study of the variation of the quantum defect against the reduced term value t in Mg II [10, p.126], that the curves haves different character with an opposite slope, for the penetrating orbits, ns and np and the non penetrating orbits, nd, nf, ng and nh. In latter case the quantum defect δ exhibit a striking regularity in its dependence on ℓ which is connected with the fact that for these series δ is determined almost entirely by the polarization of the atomic core in the field of the outer electron. According to the theory developed by Born and Heisenberg [11] and by Waller [12] this polarization gives a contribution Δ_p to the term value T that may be written as

$$\Delta p = T - T_H = \alpha_d R < r^{-4} >= A(Z)P(n,l) \qquad \text{-------(11)}$$

where $$A(Z) = \alpha_d \zeta^4$$

and

$$P(n,l) = R\frac{\langle r^{-4}\rangle}{\zeta^4} = R\frac{3n^2 - l(l+1)}{2n^5\left(l - \frac{1}{2}\right)(l+1)\left(l + \frac{3}{2}\right.}$$

Here n and ℓ are the orbital quantum numbers of the outer electron. T_H is defined in equation (4), $< r^{-4} >$ an average value of r^{-4}, r being the radius of the electron's orbit in units of a_0, and α_d the dipole polarizability of the atomic core in units of a_0^3. A(Z) is pure function of Z while p(n,ℓ) is a polynomial in n and ℓ only.

Observations reveal that the value of A obtained from nf are about 10% larger than those of ng or nh. For ng and nh the variation in A is within the experimental errors of Δ_p (about ±0.02 cm^{-1}). Therefore if we want to include the orbit nf (ℓ=3) which are still non penetrating, in the general formula the energy contribution from distortions of the higher order must be accounted for and we can include quadrupole polarization.

$$\Delta_p = \alpha_d R < r^{-4} > + \alpha_q R < r^{-6} >$$

α_q is the quadruple polrizabilty of core in units of a_0^5. $< r^{-6} >$ is defined in ref. [8]. The general formula taken the form

$$\Delta_p = A(Z)P(n,l)[1 + k(Z)q(n,l)]$$

where k (Z) stand for $\zeta^2 \alpha_q / \alpha_d$, and

$$q(n,l) = \frac{< r^{-6} >}{\zeta^6} \times \frac{\zeta^4}{< r^{-4} >}$$

The values of q(n,ℓ), p(n,ℓ) are calculated by Edlén. The above equation can be applied to any spectrum by plotting Δp(n, ℓ)/ P(n,ℓ) against q(n,ℓ). For terms that follow the two parameter plarization formula the points will then fall on a straight line with intercept A and slope Ak.

References:

1. Slater, J. C., “Quantum theory of atomic structure” (vol. I chapter 8 & 9) Mc. Graw-Hill Book Company, Inc. New York (1960).
2. Slater, J. C., “Quantum theory of atomic structure” (Vol. II chapter 17).
3. Hartee, D.R., “The calculation of atomic structure” John Wiley and Sons, Inc. New York (1960).
4. Hartree, D.R., Proc. Camb. Phil. Sco. **24** 89 (1928).
5. Condon, E.U. & Shortley, G.H. “Theory of atomic spectra” Camb. Univ. Press New York (1953).
6. C.F. Fischer “The Hartree-Fock Method for atoms” J. Wiely and Sons(1977).
7. Hartree, D.R., Proc. Camb. Phil. Soc. **24**, 111 (1928).
8. Hartree, D. R., Rep. Prog. Phys. **11**, 113 (1948).
9. R. D. Cowan “The theory of atomic structure and spectra” University of California Press, Berkeley (1981).
10. B. Edlén “ Atomic Spectra” in handbuch der Physik Springer Verlag, Vol. **27**, 80-220 (1964).
11. M. Born and W. Heisenbrg, Z. Physik **23**, 338 (1924).
12. I. Waller, Z. Physik **38**, 635 (1926).

CHAPTER - 2

Experimental Details

Almost entire work is based on the experimental recordings in normal incidence wavelength region. The spectrograms used in the present work were mainly recorded at Antigonish laboratory (Canada), and they were measured and analyzed at Aligarh. The light source was triggered spark source. The data was also supplemented by the recordings made at Zeeman laboratory (Amsterdam). The source used in this case was a sliding spark. In the following section a brief description of light sources, the spectrograph, preparation of line list and ionization separation of the spectral lines will be given.

2.1. Light Source:

Light sources which provide clear observations of the spectra under investigation are a prerequisite to spectral analysis. Our region of investigation suggested that the high voltage vacuum spark source would be a suitable source to produce spectra of multiply ionized atom. As mentioned above light source used for the present spectral recordings was a modified spark source called Triggered Spark [1]. The source is some what similar to vacuum spark source which is very well described by Bockasten [2], Svensson and Ekberg [3]. The only difference is that one can have a much better controlled spark for very low voltages (~2kV) as well as even for very high voltages (~ 15 - 20 kV) by a 30 kV trigger module TM -11A pulsed transformer. The charging condenser bank is a 14.5μF fast charging low inductance capacitor chargeable up to 20 kV. According to the need parallel combination of 14.5μF capacitors as well as big condenser bank of

120 μF (an assembly of three capacitors) are also used to obtain very high degree of ionization. Iodine plates used here were recorded for the purpose of studying multiply ionized spectra like I III – I VI using triggered spark. However, these ionization stages are also very well favoured in sliding spark source. Therefore, in recording iodine spectra, both sources have been employed. For triggered spark source, a triggedred module TM 11 is the main controller of the spark which is used to trigger the discharge. In the following section a bit more elaborate description of trigger module will be provided.

2.2. Trigger Module TM-11 A:

TM – 11 A Trigger Module is a compact versatile instrument designed to provide a high voltage trigger pulse of fast rise time. The TM-11A provides a trigger pulse of 30 kV that can be utilized for initiating communication in triggered spark gaps, xenon flashtubes or to provide an ignition type for other special devices requiring a high impedance source. In triggering these devices, the fast rising pulse of the TM-11A results in minimum delay time and jitter. Picture-1 & Picture-2 shows front and rear design of TM-11A.

Specifications of triggered module TM – 11 A:

(a) Electrical

Input :

Power : 115/230 volt AC, 50/60 Hz, 40 watts

Trigger: (1) External pulse- 50 ohms, 10 volt, 0.1 ms rise time

(2) Pushbutton (Panel)

(3) Remote Pushbutton (accessory)

Picture-1

Picture-2

Output:

Peak amplitude : 30 kV nominal

Rise time : 0.3 ms measured from 10%

90% points on leading edge of output pulse

Recycle time : 1-5 μs nominal

Isolation : 15 kV case to output terminal

(b) Mechanical

Connections:

AC input : Line cord 3 wire

External Trigger: BNC Jack

Remote control : Jones Plug

Pulse output : Threaded terminals

Controls : Off on line, switch output level, control line

The TM-11A is an integrated package consisting of a line voltage to d.c. power supply, a primary triggering circuit, a krytron switch tube and a pulse output transformer. The output is provided through ceramic high voltage bushing at the rear of the cabinet. The bushings provide limited d-c isolation between the pulse output and the ground of the cabinet. The pulse transformer is housed in an oil filled case.

The trigger module can be operated by push button control from the panel, remotely by an accessory push button cable assembly, or by a low impedance pulse generator connected through the front panel oscillator input jack. A voltage control provides variable output.

The TM-11A utilizers components in the driver, switching and output stages that minimize overall delay time. The krytron and output circuit generate a steep di/dt function to provide a very fast rising output voltage waveform.

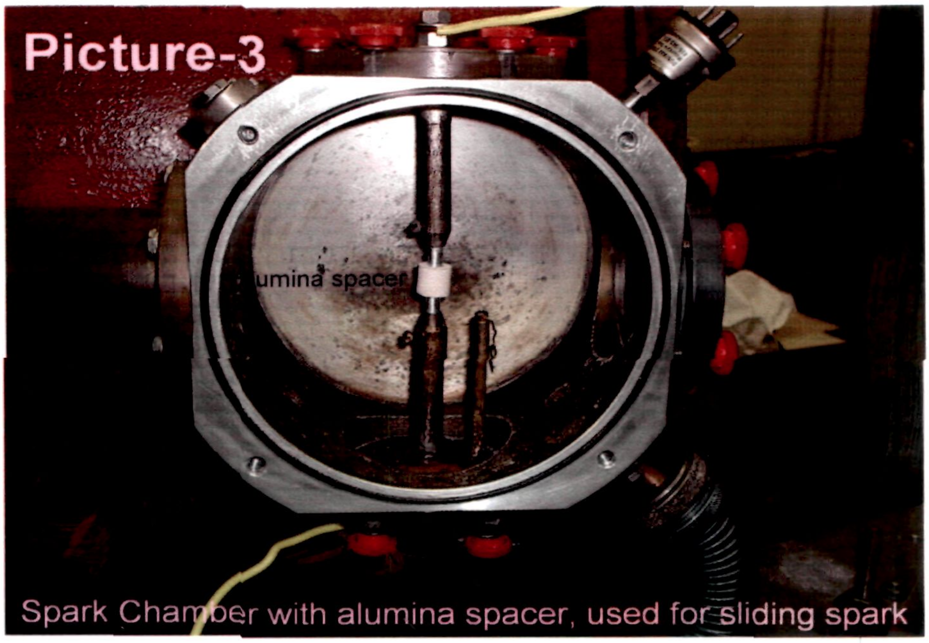
The positive (+) output terminal is normally connected to the trigger probe (for trigger spark gap) trigger wire or sparking electrode (for flash tube). The other negative (-) is connected to the adjacent main electrode or ground. When the unit is used to pulse a device such as trigger spark gap where the trigger probe and adjacent main electrode assembly are above ground, the case of the instrument must be grounded. Therefore the dc voltage (isolating voltage) between the case and output terminals can be operated up to 30 kV.

2.3. Sliding Spark Source:

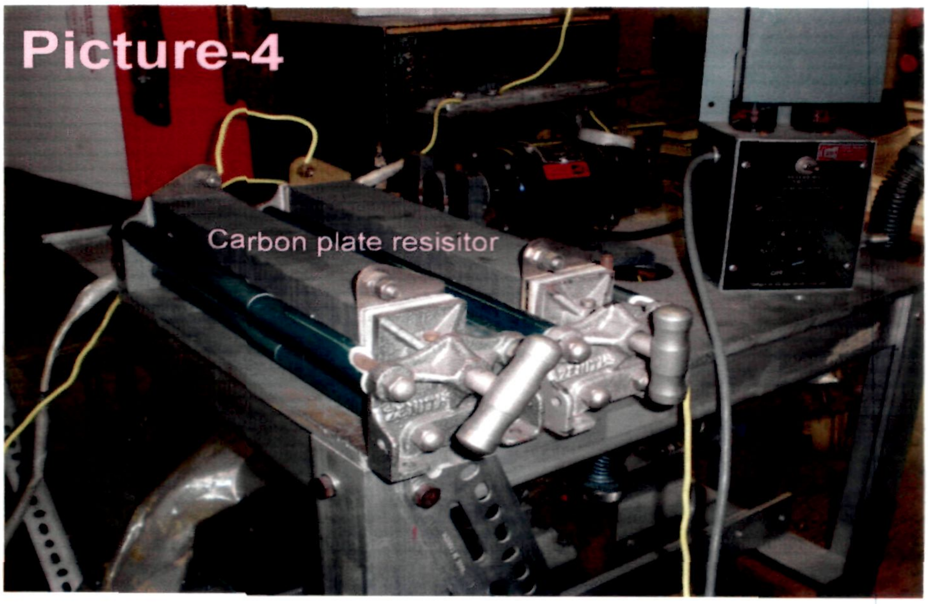
In sliding spark source, an alumina or quartz spacer is used in between the aluminum electrodes (or any metallic electrodes). Picture-3 shows sliding spark source chamber with alumina spacer. Fast charging capacitors are used at low voltages (1~2 kV) but at very high peak current. The spark between the electrodes slides through the spacer which is controlled by a rotating spark gap with the help of a motor. Peak current is monitored by oscilloscope. The fine control of the peak current is maintained with carbon plate resistor shown in picture-4. The schematic circuit diagram for sliding spark source [4] is shown in fig.2.1. Usually at about 200-300 amp peak current, lower ionization lines are recorded while for 400-1500 amp current, moderate ionizations up to VI or VII are easily recorded.

2.4.The Spectrograph:

There are varieties of spectrograph which can be used to record the spectra [5-7]. Depending on the region of investigation, proper choice of



Spark Chamber with alumina spacer, used for sliding spark



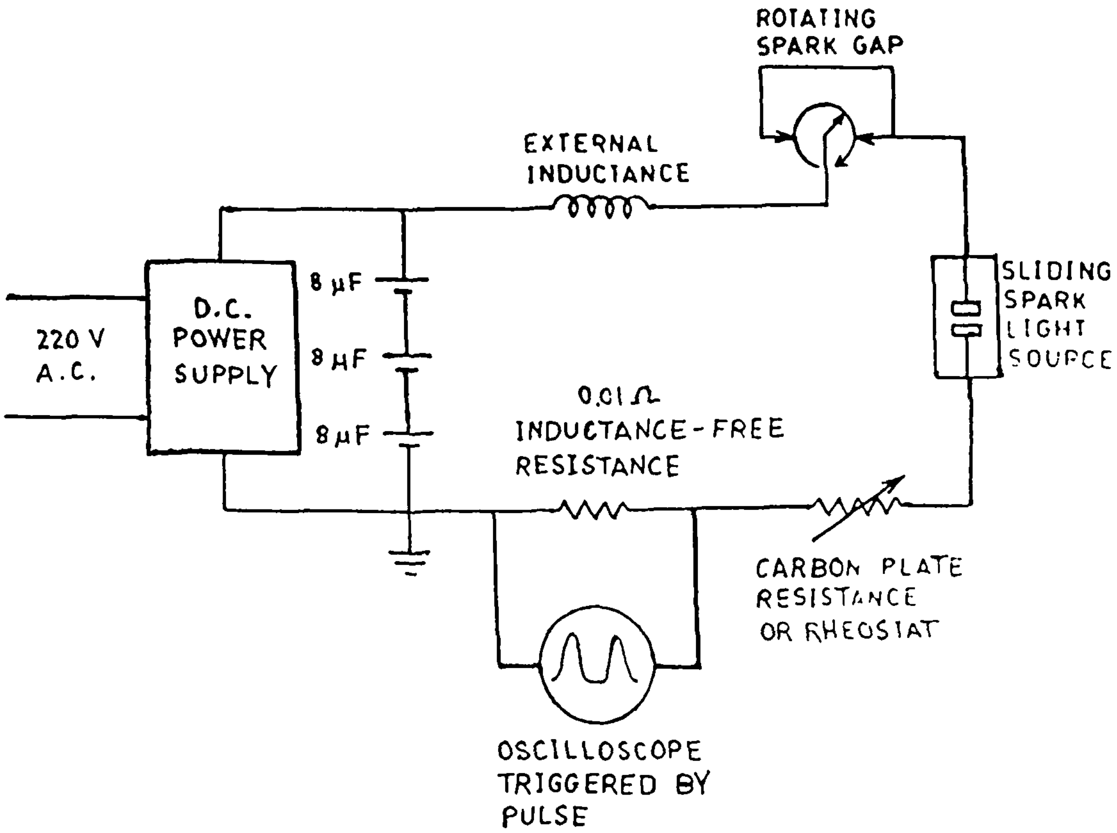


Fig. 2.1 Schematic diagram of electrical circuit for the sliding spark used at NIST.

the spectrograph is made. The work presented in this thesis covers the wavelength region from about 200 to 2080 Å which is the region of normal incidence vacuum spectrograph. The major work is based on the recordings made on a 3-m normal incidence vacuum spectrograph of Antigonish laboratory (Canada). This spectrograph is equipped with a holographic concave diffraction grating with ruling 2400 lines mm^{-1} over a ruled surface of 65x150 mm^2 giving first order inverse diffraction 1.385Å/mm. The diameter of the vacuum tank which is made up of steel is slightly greater than 30 inches. The plate holder is designed in such a way that it forms part of the Rowland circle and matching the radius of curvature of the grating. It can move in the direction perpendicular to the plane of Rowland circle and hence several positions can be chosen without disturbing the vacuum system because of its proper arrangement. The length of the plate holder is about 30 inches, so it can hold three 10 inches plates or two 15 inches plates easily. Since this spectrograph is made indigenously, its plate holder is not separated from rest of the tank. For loading and unloading the spectrograph the vacuum of the whole tank has to be destroyed. It takes about 5 -6 hours of pumping before it is ready to expose the plates. Normally $10^{-5} - 10^{-6}$ Torr of pressure is achieved during the experiment. However, in the source chamber the pressure remains a bit higher than the spectrograph tank.

The spectrograph can be used in two different settings. In the first setting the angle of incidence is 9.5^0 and it covers the wavelength region from about 200 to 1230 Å. In the second setting the incident angle is 17.5^0 and it covers from about 1050 – 2080 Å region, thus giving a fairly good overlapping region to find the correspondence in two sets of recordings. The slit is mounted on the end wall beside the plate holder tank with a valve that protects the vacuum of the main spectrograph. A side window is fitted in the tank wall just opposite (180^0) to the slit to monitor the zero-order light beam. Thus slit can be inspected visually during the exposure. The schematic diagram showing the outline of a 3-m normal incidence vacuum spectrograph is shown in Fig 2.2. The complete experimental set up can be seen in picture-5 and the plate holder in picture-6. The Zeeman lab's spectrograph was a 6.65m normal incidence vacuum spectrograph equipped with 1200 lines per mm concave grating giving the plate factor of 0.625Å mm^{-1}.

2.5. Recordings of Iodine Spectra:

Two sets of iodine spectra have been used in this work. The first set covers the wavelength region from about 300 Å to 2080 Å. This part was recorded at St. Francies Xavier University, Antigonish (Canada) by Dr. Tauheed Ahmad using a triggered spark source. The cavity of the Aluminum electrodes were packed by the Lithium Iodide powder and these electrodes were connected to a fast charging capacitor chargeable up to 20 kV. The capacitors were charged to different voltages say from 2 kV to 7 kV for different tracks. Several exposures were taken on each plate at different conditions to have a reliable ionization separation. Recording conditions can be varied by varying charging potential as the energy is proportional to V^2 and by introducing an inductance coil in the circuit as higher induction quenches the higher ionizations. The field gradient across the electrodes introduces spatial distribution of various ionization stages in the plasma. The higher ionization ions concentrated towards the anode where as the lower ionized ions are uniformly distributed in the gap between two electrodes. As the spectrograph is stigmatic the lower stages are imaged as complete length of the slit whereas the lines from other

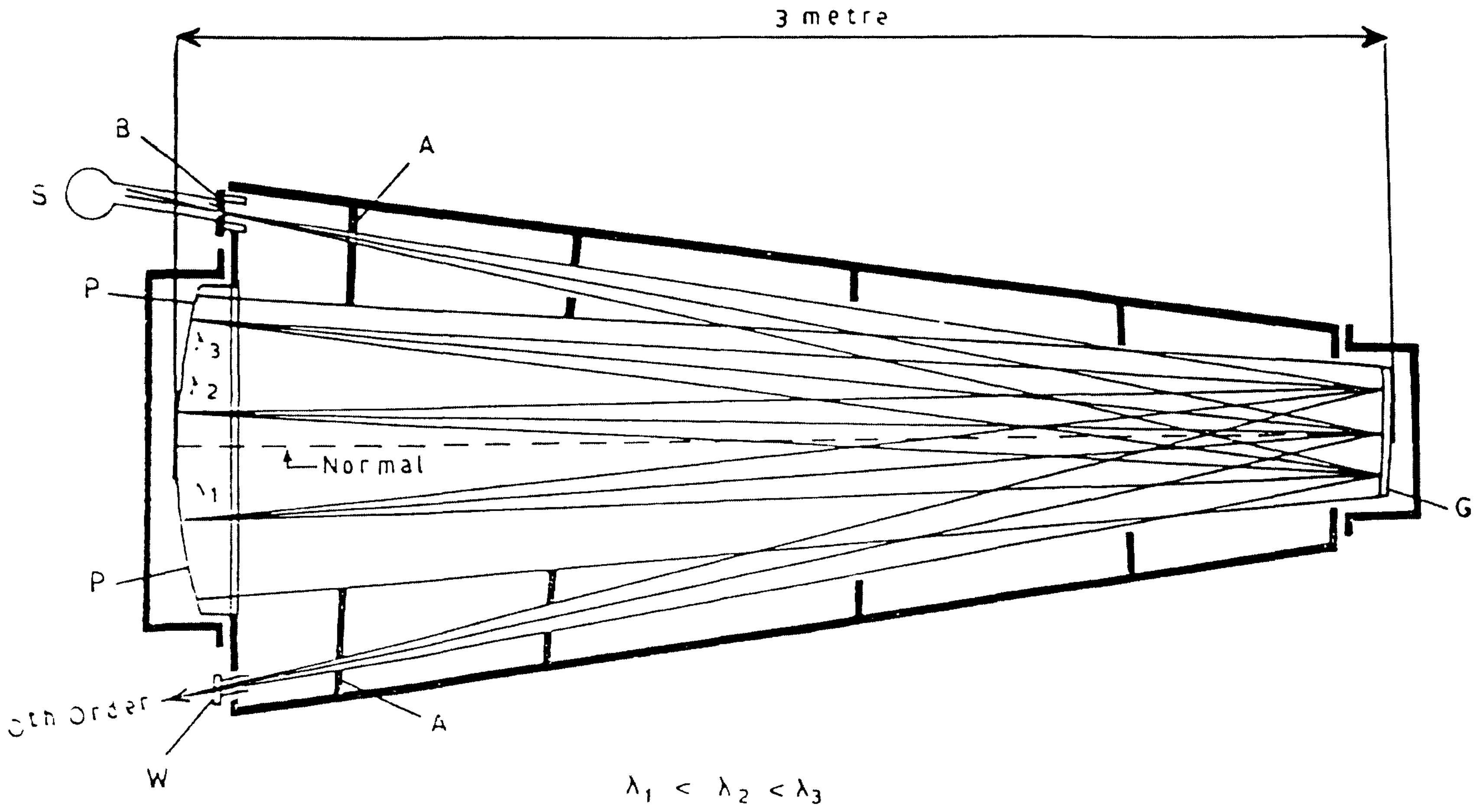
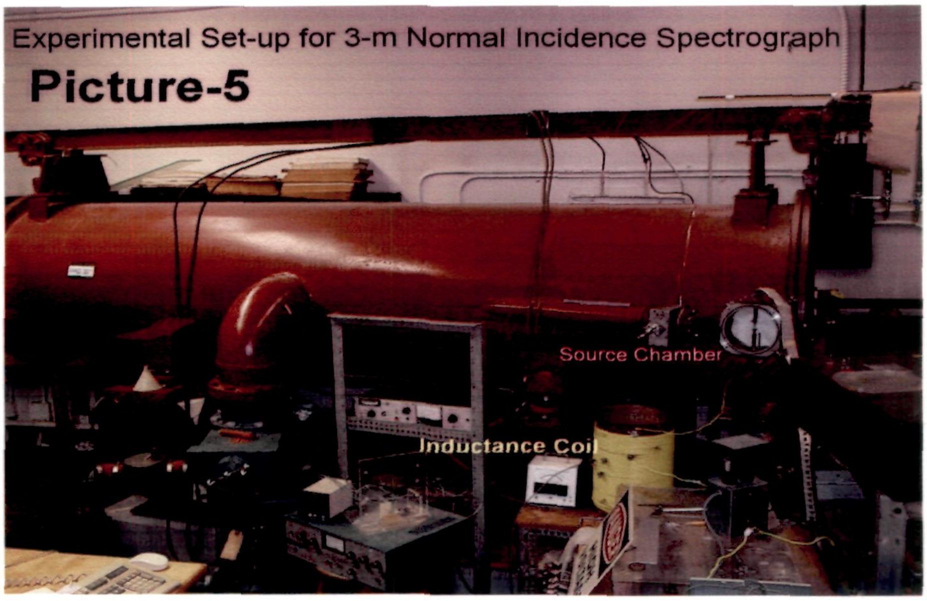
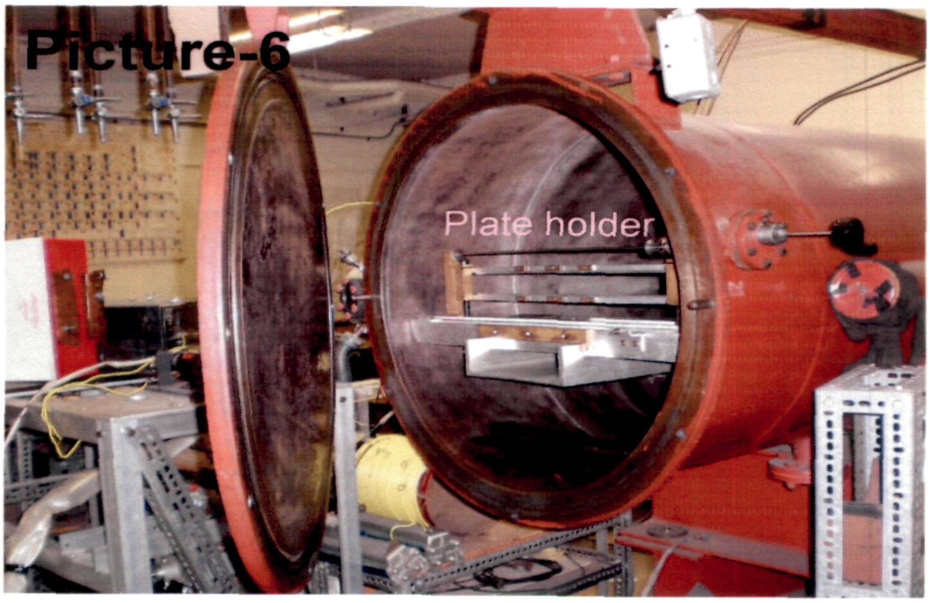


Fig. 2.2 : Outline of the 3 - meter normal incidence vacuum spectrograph (horizontal section)
Parts : Supports (A-A), slit (B), grating (G), plate holder (P-P), zero-order window (W).


Experimental Set-up for 3-m Normal Incidence Spectrograph
Picture-5
Source Chamber
Inductance Coil


Picture-6
Plate holder

stages appear shorter and shorter in length as their ionization stages enhances. This normally referred to as "pole effect" which becomes very reliable for discriminating lines of different ionization stages. The inductance coil of varied number of turns were introduced into the discharge circuit to separate out lines belonging to different ionization stages. Thus on a particular track, only lines of singly and doubly ionized iodine could be recorded and higher ionization lines could be completely eliminated with the introduction of higher number of turns in to the discharge circuit. For the wavelength region 300Å- 2080 Å, Kodak short wave radiation (SWR) plates were used. They were developed in Kodak D-19 developer and fixed in F-5 Kodak rapid fixer. For SWR plates, the temperature of the developer and fixer was about 20 ^{0}C and developing time was 2-3 minutes. After fixing the plates for about 20 minutes they are transferred to a tray of running water for about an hour. Finally it is left to dry for 30 –40 minutes. Once the plate is dried it is marked for identification. Prominent impurity lines of oxygen, carbon and aluminum etc. that get recorded on plates due to sample and electrode used were also marked. All these lines of C, O, Al are used as good internal standards to calibrate the observed spectrum.

The second set of spectra were recoded at the Zeeman laboratory (Amsterdam) by Prof. Y.N. Joshi using lithium iodide powder into the cavity of Al electrodes in the wavelength region 300 – 1300 Å. The light source in this case was a sliding spark source.

2.6.Measurements and calibration of wavelength:

Spectrograms were measured at Aligarh on the Zeiss Abbe comparator as well as in Canada by using semi automatic Grant's comparator. This can measure the position of sharp lines up to an accuracy of 0.0005 mm which corresponds to wavelength accuracy of 0.001 Å. The relative positions and intensity (which is the relative visual darkening of the plate) of each line along with the character e.g. sharpness, broadness, polarity or any specialty the line might be showing is noted down carefully.

Least Squares Fit:

Following the measurement, the most care full part of calibration of wavelength is done using an exponential curve fitting program "MOSFIT " [8] as follows

The wave length *w* of the spectral line are calculated from their positions *x* using a n- degree polynomial function

$$w = \sum_{i=0}^{n} a(i) x^{i}$$

the coefficient *a(i)* are determined from a least squares fit to a series of calibration lines with positions $x_c(r)$ and wavelength $w_c(r)$.

The criterium for the 'best fitting polynomial' is that

$$D = \sum_{r} \left\{ w_c(r) - \sum_{i=0}^{n} a(i) x_c(r)^{i} \right\}^{2}$$

is minimal.

Taking the partial derivatives to the various *a (j)*, a set of n+1 equations

$$\frac{dD}{da(j)} = 2\sum_{r} \left\{ w_c(r) - \sum_{i=0}^{n} a(i) x_c(r)^{i} \right\} . x_c(r)^{j} = 0$$

is obtained. This can be rewritten to the set of equations

$$\sum_{i=0}^{n} a(i) \sum_{r} x_c(r)^{i+j} = \sum_{r} w_c(r) . x_c(r)^{j} \qquad (j=o \text{ to } n)$$

whose solution yields the optimal values for the coefficients *a(i)*.

Tolerance:

For each calibration line, a fitted wavelength *w(r)* and a wave-length deviation $w(r)-w_c(r)$ are calculated. When the largest deviation is less than or equal to a given 'tolerance' the least squares fit is successful.

Otherwise, it is assumed that there is some thing wrong with (at least) one of the calibration lines. MOSFIT then rejects the line with the largest deviation and performs a new least squares fit without that line. This procedure is repeated until all calibration lines that were used are within the tolerance. Calibration lines that were rejected are labeled on the output file by an asterisk (*).

Standard deviation:

The 'quality of the fit' is expressed by the standard deviation of the wavelength deviation of the calibration line:

$$\sigma = \left[\sum_r \{w(r) - w_c(r)\}^2 \Big/ (N_r - n - 1) \right]^{1/2}$$

where N_r is the number of calibration lines that was used in calculation.

As mentioned earlier the impurity lines are used as internal standards. These impurity lines are very well measured by Kaufman and Edlén [9] and Bromander [10] and compiled by Kelly [11]. One can use virtually unlimited numbers of standards say for example more than 100 standards, to fit the data. The maximum degree of freedom can be up to 9 the accuracy of the wavelength measurements for sharper lines is ± 0.005 Å or better, which gives an uncertainty ($\Delta\lambda / \lambda^2$) of 0.5 cm^{-1} in the established level at 1000 Å while at 2000 Å uncertainty is only 0.125 cm^{-1}. The only lines which are complex or blended with other lines can have error greater than the said limit. Many lines of shorter wavelength also appear in second order or third order in higher wavelength region give even better accuracy than coated here.

2.7. Ionization discrimination:

Usually different tracks are measured for the analysis of different ions. For higher ionization line, normally the track without inductance coil is preferred as it contains the maximum number of lines of all ionizations. Similarly for lower ions the bottom track which is recorded with maximum inductance coil is chosen as it contains no higher ionization lines at all. A careful examination of the known lines of iodine [12-14] on the plates suggests which particular track is best for a specific ionization. Applying this criteria we establish the characteristic for I III, IV, Vand VI. This is very important part of the data preparation because entire analysis will be based on the correctness of the ionization assignment. There are several occasions when a level is established through a single allowed transition or only one strong observable transition is predicted. The right ionization separation is the only criterion to find a correct energy level in these circumstances. Due attention is paid to separates the lines of neighbouring ions. Usually the line intensities are traced on a microdensitometer for different tracks which provides excellent ionization separation. This technique is well described by Tauheed and Joshi in Ba VII [15]. A sample spectra is given in Appendix along with prominent lines of oxygen, aluminum, carbon and I III – I VI marked on it.

References:

1. U. Feldman, M. Swartz and L.I.Cohen, Rev. Sci. Instrum **38**, 1372 (1976)
2. K. Bockasten, Ark Fys **9**, 457 (1955).
3. L. A. Svensson and J. O. Ekberg, Ark Fys **40**, 145 (1069).
4. j. Reader, G.L. Epstine and J.O. Ekberg, J. Opt. Soc. Amr. **62**, 273 (1972).
5. R. A. Sawyer, "Experimental Spectroscopy" Prentice- Hall Inc,New York (1951).
6. G.R. Harisson, R.C. Lord and J. R. Loofbourow, "Practical Spectroscopy" Prentice Hall Inc, New York (1948).
7. J. A. R. Samson, "Techniques of Vacuum Ultraviolet Spectroscopy" John Wiely & Sons. Inc, New York (1967).
8. J. G. Van Hof (Formerly from Zeeman Lab Amsterdam) A computer program "Mosfit" for wavelength calibration using a polynomial fit
9. V. Kaufman and B. Edlén, J. Phys. Chem. Ref Data **3** 825 (1974).
10. T. Bromander, Ark Fys **48** 257 (1969).
11. R. L. Kelly, " Atomic and ionic spectrum line below 2000 Angstrom" Int. Book No. 0.88318-550-4 (1987).
12. A. Tauheed and Y. N. Joshi, Phys. Rev. **A 47**, 3092 (1993).
13. A. Tauheed, Y. N. Joshi and V. Kaufman, J. Phys.B (UK) **31**, 393 (1991).
14. A. Tauheed, Y. N. Joshi and E. H. Pinnington, Phys. Scr. **56**, 289 (1997).
15. A.Tauheed and Y.N.Joshi, "Analysis of the $5s^2 5p^2$, $5s5p^3$, $5s^2$ 5p6s and $5s^2$ 5p5d configurations of Ba VII " Physica Scripta **46**, 403 (1992).

CHAPTER- 3

The Third Spectrum of Iodine: I III

3.1. Introduction:

The doubly ionized iodine (I III) has 51 electrons and its electronic distribution is given as follows:

$$1s^2\ 2s^2\ 2p^6,\ 3s^2\ 3p^6\ 3d^{10},\ 4s^2\ 4p^6\ 4d^{10},\ 5s^2\ 5p^3$$

Thus its ground configuration is $5s^25p^3$ and it belongs to the Sb I isoelectronic sequence. The lowest excited configurations are $5s5p^4$, $5s^2\ 5p^2$ nd ($n \geq 5$) and $5s^2\ 5p^2$ ns ($n \geq 6$). The further excitation is of the type $5s^2\ 5p^2$ (np + nf) and $5s^25p^3$ (5d + 6s). The first analysis of this spectrum was reported by Seth [1], followed by Krishnamurty and Parthasardhy [2]. However, these analyses were judged to be unreliable by Moore and were not included in Atomic Energy levels Vol. III [3]. This spectrum has not been investigated since 1949 until very recently [4]. The primary reason for this was the fact that the three lowest excited configurations viz. $5s5p^4$, $5p^25d$ and $5p^26s$ interact strongly and make situation very complex. A reliable analysis is impossible without sophisticated calculations. The multiconfiguration interaction calculations [5] have become available for moderately powered computers quite recently. Sn I [6-10] and Sb I [11-16] isoelectronic ions have been studied extensively to understand the structure of 5d open sub shell ions. The first reliable analysis of I III was carried out by Tauheed and Joshi [4]. They established all the five levels of ground configuration and three lowest excited configurations, viz. $5s5p^4$, $5p^25d$ and $5p^26s$. Surprisingly none of the earlier reported analysis could be verified. In the present work the author has reinvestigated the third spectrum of iodine and extended the existing analysis to include $5p^2 6d$, $5p^2 7d$, $5p^2 7s$ and $5p^2 8s$ configurations.

3.2. The Term Structure of I III:

Ground configuration of I III is $5s^2 5p^3$ with five levels. The lowest excited configuration is $5p^4$ due to core excitation. The other excitation is from outer shell like $5p^2nd$, $5p^2ns$, $5p^2np$ and $5p^2nf$. The detailed structure is as follows:

$5s^2 5p^3$: ${}^4S_{3/2}$, ${}^2D_{3/2}$, ${}^2D_{5/2}$, ${}^2P_{1/2}$, ${}^2P_{3/2}$

$5s\,5p^4$: $({}^3P)$ ${}^4P_{1/2,\,3/2,\,5/2}$; ${}^2P_{1/2,\,3/2}$

$({}^1D)$ ${}^2D_{3/2,\,5/2}$

$({}^1S)$ ${}^2S_{1/2}$

$5s^2 5p^2\ nd$: $({}^3P)$ ${}^4P_{1/2,\,3/2,\,5/2}$; ${}^4D_{1/2,\,3/2,\,5/2,\,7/2}$; ${}^4F_{3/2,\,5/2,\,7/2,\,9/2}$

${}^2P_{1/2,\,3/2}$; ${}^2D_{3/2,\,5/2}$; ${}^2F_{5/2,\,7/2}$

$({}^1D)$ ${}^2S_{1/2}$; ${}^2P_{1/2,\,3/2}$; ${}^2D_{3/2,\,5/2}$; ${}^2F_{5/2,\,7/2}$; ${}^2G_{7/2,\,9/2}$

$({}^1S)$ ${}^2D_{3/2,\,5/2}$

$5s^2 5p^2\ ns$: $({}^3P)$ ${}^4P_{1/2,\,3/2,\,5/2}$; ${}^2P_{1/2,\,3/2}$

$({}^1D)$ ${}^2D_{3/2,\,5/2}$

$({}^1S)$ ${}^2S_{1/2}$

$5s^2 5p^2\ np$: $({}^3P)$ ${}^4S_{3/2}$, ; ${}^4P_{1/2,\,3/2,\,5/2}$; ${}^4D_{1/2,\,3/2,\,5/2,\,7/2}$

${}^2S_{1/2}$; ${}^2P_{1/2,\,3/2}$; ${}^2D_{3/2,\,5/2}$

$({}^1D)$ ${}^2P_{1/2,\,3/2}$; ${}^2D_{3/2,\,5/2}$; ${}^2F_{5/2,\,7/2}$

$({}^1S)\ {}^2P_{1/2,\,3/2}$

$5s^2 5p^2\ nf$: $({}^3P)\ {}^4D_{1/2,\,3/2,\,5/2,\,7/2}$; ${}^4F_{3/2,\,5/2,\,7/2,\,9/2}$; ${}^4G_{5/2,\,7/2,\,9/2,\,11/2}$

${}^2D_{3/2,\,5/2}$; ${}^2F_{5/2,\,7/2}$; ${}^2G_{7/2,\,9/2}$

$({}^1D)\ {}^2P_{1/2,\,3/2}$; ${}^2D_{3/2,\,5/2}$; ${}^2F_{5/2,\,7/2}$; ${}^2G_{7/2,\,9/2}$; ${}^2H_{9/2,\,11/2}$

$({}^1S)\ {}^2F_{5/2,\,7/2}$

3.3. Results and discussion:

The spectrum of doubly ionized iodine (I III) is Sb I like. In recent years, experimental sufficient data on its isoelectroinc members is now available from Te II to La VII [11-16]. Hartree-Fock calculations with relativistic correction were carried out using Cowan's computer code [5] involving multiconfigurations for incorporating all the possible interactions among the same parity configurations. The configurations included for odd parity system were $5s^25p^3$, $5s^2p^24f$, $5s^25p^26p$ and for even parity matrix $5s5p^4$, $5s^25p^25d$, $5s^25p^26d$, $5s^25p^27d$, $5s^25p^26s$, $5s^25p^27s$ and $5s^25p^28s$. The initial scaling (ratio of the least squares fitted energy parameter to the Hartree-Fock calculated parameter values) were obtained by the extrapolation of the least squares fitted parameters from Te II to La VII [11-16].

The $5s^25p^3$-($5s5p^4$ + $5s^25p^25d$ + $5s^25p^26s$) array:

As mentioned earlier that this array was investigated by Tauheed and Joshi [4]. They established all the five levels of the ground configuration and all but two levels of the first three lowest excited configurations viz. $5s5p^4$, $5s^25p^25d$ and $5s^25p^26s$ configurations. The two unknown levels of

$5p^2 5d$ are $(^3P)^4F_{9/2}$ and $(^1D)^2G_{9/2}$, they do not combine with ground levels as the highest J value of any ground level is 5/2. It would be appropriate to mention about the early investigations of Seth [1] and Krishnasmurty and Parthasradhy [2]. Seth studied $5s^2 5p^2(5d + 6s)$ - $5s5p^2 6p$ transitions and reported ten even parity levels. However, none of these levels agreed with the observed levels of Tauheed and Joshi [4]. Krishnamurty and parthasardhy [2] did not publish any level but reported three intervals $5s^2 5p^2 6s(^4P_{3/2}$-$^4P_{1/2})$, $(^2D_{5/2}$-$^2D_{3/2})$ and $(^2P_{3/2}$- $^2P_{1/2})$ as 6313, 11254 and 1609 cm^{-1} respectively. However, this interval neither correspond to the predicted intervals nor to the observed levels. Consequently, these works were rejected. One of the unknown J = 1/2 level in ref. [4] has now been found at 158041 cm^{-1}. This new level fits nicely in the least squares fitted calculations. About 85% levels are quite unambiguous and LS designation has been assigned without any problem only two J=5/2 levels at 138478 and 144174cm^{-1} has been assigned second largest component. The agreement between calculated and experimental level is quite good. The standard deviation is only 196 cm^{-1}. One hundred seventeen lines have been classified in this array. All the levels reported earlier have been found quite satisfactory and are, therefore, confirmed in this work.

The $5s^2 5p^3$-$5s^2 5p^2$ (6d + 7d + 7s + 8s) array:

During the course of investigation of I IV [17], we noticed a large number of lines with moderate intensities showing I III ionization characteristic were present on the plates. *Ab initio* calculations predict these lines as the transitions between $5s^2 5p^3$-$5p^2(6d + 7d + 7s + 8s)$ configurations. Since $5p^2 5d$ and $5p^2 6s$ have been studied successfully, we applied the same parameter scaling for $5p^26d$ and $5p^27s$ configurations and obtained very precise predictions for the levels of these configurations.

Based on the theoretical predictions, $5s^25p^3$-$5s^25p^2(6d + 7s)$ transitions were identified. Since I III and I IV spectra were developed very well on the plates, consequently all the levels except J=7/2 were found with good supporting transitions and were established without much problem. Least squares fitted parametric calculations provided the precise position for the J=7/2 levels. All the 7/2 levels were identified only after completion of analysis. The remaining lines showing I III ionization characteristic were used to established J=7/2 levels. Naturally all the 7/2 levels were necessarily based on single transition. However, with reliable ionization separation and least squares calculations these levels could also be found with satisfaction. All the levels of $5p^26d$ and $5p^27s$ fitting nicely in the least squares fit.

Adapting the same approach for the scaling of the energy parameters for $5p^27d$ and $5p^2$ 8s configurations, analysis was further extended to locate the levels of these two configurations. Twenty-four levels were found with supporting transitions in this array, which were sufficient to run least squares fitted parametric calculations to guide the unknown levels. All the level of this array was found except J=9/2 which do not give any electric dipole transition ($\Delta J > 1$). These levels can be established only through the higher excitations like transitions from $5s^25p^2(4f + 6p)$. All the levels established in I III have already been published in Physica Scripta [18]

The $5s^25p^4(4f + 6p)$ configurations:

The *ab initio* calculations were performed for $5s^25p^2(5d + 6s)$ – $5s^25p^2(4f + 6p)$ transition array involving other effective interacting configurations as well. As it is evident from Fig. 3.1 that these two configurations viz.$5p^24f$ and $5p^26p$ lie close to the $5s^25p^25d$ and $5p^25p^26s$ configurations, consequently, their transitions lie only partially in the region of our investigation. Therefore, these two configurations could not be studied at the moment. However with the availability of data in the higher wavelength region, we plan to study these configurations in near future.

In summary, **307** lines have been established in this spectrum and they are given in Table 3.1. The least squares fitted levels of ground configuration $5s^25p^3$ are given in Table 3.2 and the corresponding fitted energy parameters in Table 3.3. **One hundred fifteen** energy levels belonging to the excited configurations $5s5p^4$, $5s^25p^2(5d + 6d + 7d + 6s + 7s + 8s)$ have been established and they are given in Table 3.4 along with their LS percentage composition. The least squares fitted energy parameters are given in Table 3.5. The agreement between observed and calculated level values is good. The standard deviation of the least squares fitted calculations for ground and excited configuration are 5 cm^{-1} and 170 cm^{-1} respectively. More than seventy percent levels showing LS purity higher than 50% and are quiet unambiguous, therefore, LS designation has been adapted. The location of various even parity configurations and their energy spread is shown in Fig. 3.2.

3.4. Ionization potential:

The ionization limit of I III has not been reported before. If three consecutive series members in a spectrum are known then a reliable ionization limit can be obtained by using Edlén's formula [19]. Based on our present investigation we have at least two 3-member series $5p^2ns$ (n =

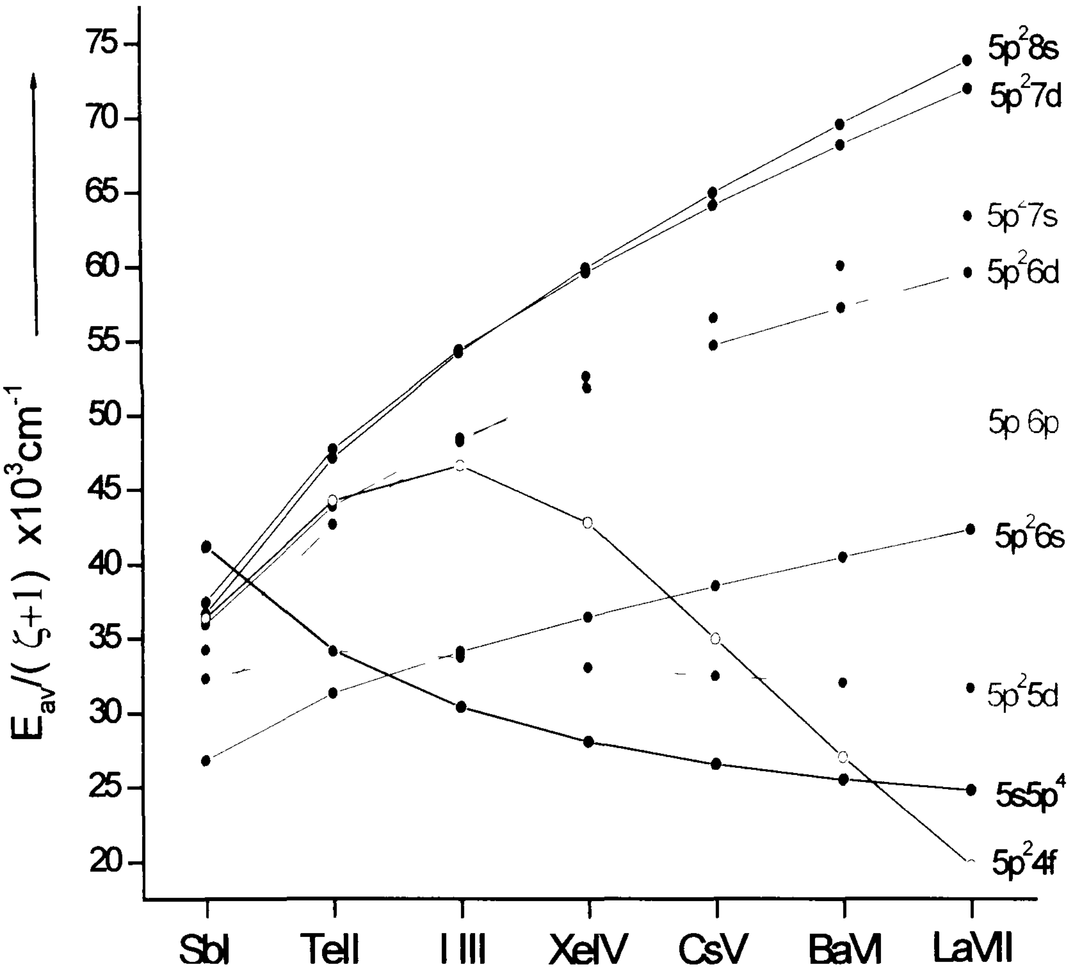


Fig. 3.1. $E_{av}/(\zeta+1)$ for Sb I isoelectronic sequence where filled circles represent even parity & hollow circles the odd parity configurations.

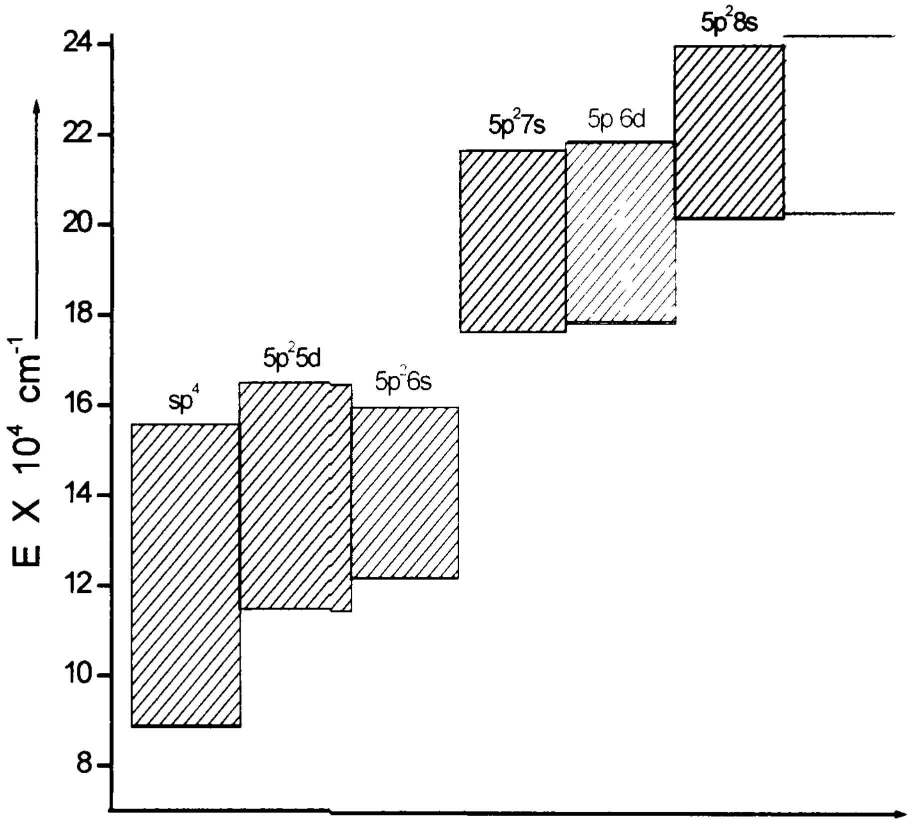


Fig. 3.2. Energy spread of various even parity configurations in I III.

6,7 and 8) and $5p^2$ nd (n=5,6 and 7) limiting on various $5p^2$ limits of I IV. The value of calculated limit is less reliable if percentage mixing of levels of particular series member changes considerably. Allowance was made for this factor while averaging the calculated value. The ionization limit of I III is calculated to be 238500 ± 200 cm^{-1} (29.56 ± 0.02 eV) limiting on I IV $5s^25p^2\ ^3P_0$.

References:

1. J. B. Seth, Proc. Indian Acad. Sci. 1A, 593 (1935).
2. S. G. Krishnamurty and T. V. Parthasardhy, Nature 164, 407 (1949).
3. C. E. Moore, Atom Energy Levels, Natl. Bur. Stand.(U. S.) Circ. No. 467 (U. S. GPO, Washington, DC, 1957), Vol. III.
4. A. Tauheed and Y. N. Joshi, Phys. Rev. A **47**, 3092 (1993).
5. R. D. Cowan, The Theory of Atomic Structure and Spectra (University of California Press, Berkeley, 1981); Cowan Code of computer programs suited for VAX-type computers provided by Dr. Cowan to authors' research group.
6. Y.N. Joshi, A.Tauheed and I.G. Davison, " The analysis of the$5s^2 5p^2$, $5s5p^3$, $5s^25p5d$ and $5s^25p6s$ configurations of Te III" Canad. J. Phys. **70** , 740 (1992).
7. A.Tauheed, Y.N. Joshi and V. Kaufman, "The analysis of the $5s^25p^2$, $5s5p^3$, $5s^2$ 5p6s and $5s^2$ 5p5d configurations of I IV " J. Phys B (UK) **24** , 3701 (1991).
8. A.Tauheed, Y.N. Joshi, V. Kaufman, J.Suger and E.H.Pinnington, "Analysis of the $5s^25p^2$ - ($5s5p^3$ +$5s^25p5d$ + $5s^25p6s$) transitions of four-times ionized xenon (Xe V)" J. Opt. Soc.Amr.**B 10,** 561 (1993).
9. A. Tauheed , Y.N. Joshi and V. Kaufman, " Analysis of the fourwest configurations of five-times ionized cesium (Cs VI)"Physica Scripta **44** 579 (1991).
10. A.Tauheed and Y.N.Joshi, "Analysis of the $5s^25p^2$, $5s5p^3$, $5s^2$ 5p6s and $5s^2$ 5p5d configurations of Ba VII " Physics Scripta **46,** 403 (1992).

11.M. Bernarda Handrup and J.E. Mack Physica **30**, 1245 (1964).

12.A. Tauheed and Y.N. Joshi, "Analysis of the third spectrum of iodine: I III", Physical Reviev A, **47**, 3092 (1993).

13.A.Tauheed, Y.N. Joshi and E.H.Pinnington,"Revised and extended analysis of the $5s^2 5p^3$,$5s5p^4$, $5s^25p^25d$ and $5s^25p^2 6s$ configurations of trebly ionized xenon (Xe IV)" Physica Scripta. **47**, 555 (1993).

14.A.Tauheed and Y.N .Joshi, "Analysis of the four times ionized cesium (Cs V)" Physica Scripta **47**, 550 (1993).

15.A. Tauheed and Y.N. Joshi. "Analysis of the Ba VI Spectrum" Physica. Scripta. **49** , 335 (1994).

16.R.R. Gayasov, Y.N. Joshi and A. Tauheed " Seventh Spectrum of Lanthanum: La VII " Physica Scripta **57**, 565 (1998).

17.A.Tauheed, Y.N. Joshi and Anjum Naz "Extended analysis of the fourth spectrum of iodine: I IV" Physica Scripta **69** , 283 (2004).

18.A.Tauheed, Y.N. Joshi and Anjum Naz "Extended analysis of doubly ionized iodine spectrum: I III" Physicsa Scripta **69**, 289 (2004).

19.B. Edlén " Atomic Spectra" in Handbuch der Physik Springer Verlag, Vol. **27**, 80-220 (1964).

Table 3.1. Classified lines of I III Spectrum

Wavelength λ(Å)	Wavenumber ν(cm^{-1})	Int[†]	Ch[*]	Classification	diff.[a] Δλ(Å)
453.685	220417.2	2		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^1D)\ ^2D_{3/2}$	-0.002
473.522	211183.3	15		$5p^3\ ^2P_{1/2}$ - $5p^28s\ (^1S)\ ^2S_{1/2}$	0.000
474.682	210667.5	35		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^1S)\ ^2D_{3/2}$	-0.002
478.354	209050.0	50		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^4P_{1/2}$	-0.001
478.503	208985.3	5		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^1D)\ ^2D_{5/2}$	-0.002
478.614	208936.5	55		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^4P_{3/2}$	-0.001
478.947	208791.5	50		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^4P_{5/2}$	-0.001
479.147	208704.4	45		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^1D)\ ^2D_{3/2}$	0.003
479.668	208477.4	50		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^1D)\ ^2F_{5/2}$	0.001
479.949	208355.6	5		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^1D)\ ^2P_{1/2}$	0.000
480.502	208115.7	55		$5p^3\ ^4S_{3/2}$ - $5p^28s\ (^3P)\ ^4P_{5/2}$	-0.002
480.562	208089.9	35		$5p^3\ ^2D_{3/2}$ - $5p^28s\ (^1D)\ ^2D_{3/2}$	-0.001
480.892	207947.1	25		$5p^3\ ^2D_{3/2}$ - $5p^28s\ (^1D)\ ^2D_{5/2}$	-0.002
484.145	206549.8	30		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^1D)\ ^2P_{3/2}$	-0.008
485.926	205792.5	30		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^1D)\ ^2D_{5/2}$	0.004
486.261	205651.0	30		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^1S)\ ^2D_{5/2}$	0.000
486.581	205515.7	35		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^1D)\ ^2D_{3/2}$	-0.001
486.814	205417.4	45		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^1D)\ ^2G_{7/2}$	0.000
487.025	205328.2	30		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^1S)\ ^2D_{3/2}$	0.002
487.122	205287.5	50	W	$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^4D_{3/2}$	0.001
			D	$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^1D)\ ^2F_{5/2}$	-0.001
487.263	205227.8	35		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^2F_{5/2}$	-0.001
488.142	204858.5	30		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^1D)\ ^2F_{7/2}$	0.000
488.388	204755.3	60		$5p^3\ ^2D_{5/2}$ - $5p^28s\ (^1D)\ ^2D_{5/2}$	0.002
488.675	204634.8	60		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^4F_{5/2}$	-0.001
489.304	204371.9	50		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^2P_{3/2}$	0.000
490.153	204017.8	60		$5p^3\ ^4S_{3/2}$ - $5p^28s\ (^3P)\ ^4P_{3/2}$	0.000

501.135	199547.2	45		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^1S)\ ^2D_{5/2}$	-0.003
502.632	198952.8	35		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^1D)\ ^2S_{1/2}$	-0.003
503.369	198661.4	45		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^1D)\ ^2P_{3/2}$	0.000
503.918	198445.0	70		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^1D)\ ^2D_{5/2}$	0.000
504.647	198158.4	45		$5p^3\ ^4S_{3/2}$ - $5p^27d\ (^3P)\ ^4F_{3/2}$	0.002
506.006	197626.3	60	B	$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^3P)\ ^2D_{5/2}$	0.004
506.629	197383.0	65		$5p^3\ ^4S_{3/2}$ - $5p^28s\ (^3P)\ ^4P_{1/2}$	0.002
507.036	197224.7	15		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^3P)\ ^4P_{3/2}$	0.002
507.230	197149.2	35		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^1D)\ ^2P_{3/2}$	-0.001
507.952	196869.1	15		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^1D)\ ^2S_{1/2}$	-0.001
508.335	196720.6	45		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^1D)\ ^2D_{3/2}$	0.002
509.284	196354.1	30		$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^1S)\ ^2D_{5/2}$	0.004
509.505	196269.0	60		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^1D)\ ^2F_{5/2}$	-0.001
511.320	195572.1	2		$5p^3\ ^4S_{3/2}$ - $5p^27s\ (^1D)\ ^2D_{3/2}$	0.003
512.247	195218.3	20		$5p^3\ ^4S_{3/2}$ - $5p^27s\ (^1D)\ ^2D_{5/2}$	0.007
513.556	194720.7	65		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^2F_{7/2}$	0.000
514.092	194517.9	45		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^2D_{3/2}$	0.000
514.300	194438.9	50	B	$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^2D_{5/2}$	-0.004
515.370	194035.5	20		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^4P_{3/2}$	-0.001
515.759	193889.0	55		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^4P_{5/2}$	0.002
516.592	193576.3	70	D	$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^3P)\ ^4D_{3/2}$	0.002
				$5p^3\ ^2D_{5/2}$ - $5p^28s\ (^3P)\ ^2P_{3/2}$	-0.002
516.751	193516.8	75		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^3P)\ ^2F_{5/2}$	0.000
517.323	193303.0	30		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^4D_{7/2}$	0.000
517.563	193213.3	45		$5p^3\ ^2D_{5/2}$ - $5p^28s\ (^3P)\ ^4P_{5/2}$	0.001
519.049	192660.2	20		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^3P)\ ^2P_{3/2}$	0.003
519.364	192543.3	60		$5p^3\ ^2D_{3/2}$ - $5p^28s\ (^3P)\ ^2P_{1/2}$	-0.004
519.999	192308.0	40		$5p^3\ ^2D_{3/2}$ - $5p^28s\ (^3P)\ ^4P_{3/2}$	-0.002
521.347	191810.8	45		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^1D)\ ^2P_{3/2}$	0.001
522.110	191530.6	25		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^1D)\ ^2S_{1/2}$	0.001
523.397	191059.4	60		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^1D)\ ^2D_{5/2}$	-0.002
525.413	190326.5	25		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^2F_{5/2}$	0.000
525.863	190163.5	50		$5p^3\ ^2P_{3/2}$ - $5p^28s\ (^1D)\ ^2D_{3/2}$	0.001

527.123	189709.0	40		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^4F_{7/2}$	0.000
527.788	189470.0	10		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^2P_{3/2}$	0.003
528.779	189115.0	30		$5p^3\ ^2D_{5/2}$ - $5p^28s\ (^3P)\ ^4P_{3/2}$	0.005
534.136	187218.1	50		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^3P)\ ^4D_{5/2}$	-0.002
534.255	187176.7	80	B	$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^2D_{3/2}$	0.003
534.548	187073.9	60		$5p^3\ ^2P_{1/2}$ - $5p^26d\ (^1S)\ ^2D_{3/2}$	-0.001
535.523	186733.5	60		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^1D)\ ^2D_{5/2}$	0.003
536.115	186527.1	15		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^2D_{5/2}$	0.000
536.339	186449.2	30		$5p^3\ ^2D_{3/2}$ - $5p^27d\ (^3P)\ ^4F_{3/2}$	-0.002
538.580	185673.4	45		$5p^3\ ^2D_{3/2}$ - $5p^28s\ (^3P)\ ^4P_{1/2}$	-0.001
538.863	185575.9	70	B	$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4P_{1/2}$	-0.006
539.501	185356.4	70		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4P_{3/2}$	-0.002
539.929	185209.6	25		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^3P)\ ^2P_{1/2}$	0.000
540.188	185120.8	55		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^3P)\ ^2D_{3/2}$	-0.002
540.458	185028.2	75		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4D_{5/2}$	-0.001
540.507	185011.6	65		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^1D)\ ^2D_{3/2}$	-0.003
541.270	184750.8	5		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^3P)\ ^4P_{1/2}$	0.001
541.834	184558.5	65		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^1D)\ ^2F_{5/2}$	-0.002
541.879	184543.0	40	B	$5p^3\ ^4S_{3/2}$ - $5p^27s\ (^3P)\ ^2P_{3/2}$	0.000
542.955	184177.4	45		$5p^3\ ^2P_{1/2}$ - $5p^28s\ (^3P)\ ^2P_{3/2}$	0.002
543.888	183861.4	70		$5p^3\ ^2D_{3/2}$ - $5p^27s\ (^1D)\ ^2D_{3/2}$	0.003
544.188	183759.9	35		$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^1D)\ ^2P_{3/2}$	0.001
544.295	183723.9	70		$5p^3\ ^4S_{3/2}$ - $5p^27s\ (^3P)\ ^4P_{5/2}$	-0.003
544.926	183511.3	60		$5p^3\ ^2D_{3/2}$ - $5p^27s\ (^1D)\ ^2D_{5/2}$	-0.003
545.676	183259.0	20		$5p^3\ ^2D_{5/2}$ - $5p^27d\ (^3P)\ ^4F_{3/2}$	-0.003
549.192	182085.8	60		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4D_{3/2}$	0.002
549.997	181819.3	65		$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^1D)\ ^2D_{3/2}$	0.003
550.141	181771.5	80		$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^1D)\ ^2G_{7/2}$	0.000
550.179	181759.0	55		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^2F_{5/2}$	-0.001
550.250	181735.6	65		$5p^3\ ^2P_{3/2}$ - $5p^26d\ (^1S)\ ^2D_{3/2}$	0.001
550.599	181620.4	60		$5p^3\ ^2P_{3/2}$ - $5p^26d\ (^1S)\ ^2D_{5/2}$	-0.001

551.370	181366.5	70		$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^1D)\ ^2F_{5/2}$	0.003
552.400	181028.2	35		$5p^3\ ^2P_{3/2}$ - $5p^27s\ (^1S)\ ^2S_{1/2}$	0.000
552.518	180989.7	15		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^3P)\ ^4D_{3/2}$	-0.002
552.963	180844.0	15		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4D_{1/2}$	0.001
553.494	180670.4	5		$5p^3\ ^2D_{5/2}$ - $5p^27s\ (^1D)\ ^2D_{3/2}$	0.005
554.153	180455.6	75		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4F_{5/2}$	-0.002
554.569	180320.1	80		$5p^3\ ^2D_{5/2}$ - $5p^27s\ (^1D)\ ^2D_{5/2}$	-0.001
554.760	180258.2	10		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^3P)\ ^4D_{1/2}$	0.000
555.048	180164.7	70	B	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^1D)\ ^2F_{7/2}$	0.000
555.229	180105.9	65		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^2P_{3/2}$	0.002
555.264	180094.4	79	B	$5p^3\ ^4S_{3/2}$ - $5p^27s\ (^3P)\ ^2P_{1/2}$	-0.010
555.703	179952.4	45		$5p^3\ ^2P_{1/2}$ - $5p^28s\ (^3P)\ ^2P_{1/2}$	0.004
556.230	179781.7	45		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^3P)\ ^2D_{3/2}$	0.002
556.476	179702.2	25		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^3P)\ ^2D_{5/2}$	0.000
556.765	179609.0	70		$5p^3\ ^4S_{3/2}$ - $5p^27s\ (^3P)\ ^4P_{3/2}$	0.003
558.177	179154.8	75	B	$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^3P)\ ^4P_{5/2}$	-0.001
559.158	178840.3	35		$5p^3\ ^2P_{3/2}$ - $5p^28s\ (^3P)\ ^2P_{3/2}$	0.000
569.903	175468.6	55		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^2D_{3/2}$	-0.005
571.436	174997.8	35		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^3P)\ ^4F_{5/2}$	0.001
572.028	174816.6	54		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^2D_{5/2}$	0.000
572.289	174737.0	45		$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^3P)\ ^2P_{3/2}$	-0.005
572.925	174542.9	80		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4P_{5/2}$	0.005
573.455	174381.7	10		$5p^3\ ^2P_{3/2}$ - $5p^28s\ (^3P)\ ^4P_{3/2}$	-0.002
573.512	174364.2	45		$5p^3\ ^2P_{1/2}$ - $5p^26d\ (^1D)\ ^2P_{3/2}$	-0.005
575.177	173859.5	20		$5p^3\ ^2P_{1/2}$ - $5p^27d\ (^3P)\ ^4F_{3/2}$	0.003
575.886	173645.4	60		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^4P_{3/2}$	-0.001
576.347	173506.6	65		$5p^3\ ^4S_{3/2}$ - $5p^26d\ (^3P)\ ^4F_{3/2}$	0.002
576.977	173317.2	65		$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^4D_{5/2}$	0.000
577.693	173102.3	70		$5p^3\ ^4S_{3/2}$ - $5p^27s\ (^3P)\ ^4P_{1/2}$	0.003
577.749	173085.6	15		$5p^3\ ^2P_{1/2}$ - $5p^28s\ (^3P)\ ^4P_{1/2}$	-0.002
578.594	172832.8	75		$5p^3\ ^2D_{3/2}$ - $5p^27s\ (^3P)\ ^2P_{3/2}$	-0.001
579.509	172559.8	75	B	$5p^3\ ^2P_{1/2}$ - $5p^26d\ (^1D)\ ^2P_{1/2}$	-0.002
579.969	172422.9	65		$5p^3\ ^2P_{1/2}$ - $5p^26d\ (^1D)\ ^2D_{3/2}$	-0.001

580.466	172275.4	75	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^2D_{3/2}$	0.005
581.352	172012.7	25	$5p^3\ ^2D_{3/2}$ - $5p^27s\ (^3P)\ ^4P_{5/2}$	-0.001
581.778	171887.0	85	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^2F_{7/2}$	0.000
582.662	171626.2	80	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^2D_{5/2}$	0.000
583.853	171275.9	45	$5p^3\ ^2P_{1/2}$ - $5p^27s\ (^1D)\ ^2D_{3/2}$	-0.005
586.667	170454.5	65	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^4P_{3/2}$	0.001
586.938	170375.8	70	$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^4D_{3/2}$	0.000
587.800	170125.8	90	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^4D_{5/2}$	0.003
588.070	170047.9	80	$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^2F_{5/2}$	0.001
589.479	169641.3	70	$5p^3\ ^2D_{5/2}$ - $5p^27s\ (^3P)\ ^2P_{3/2}$	0.003
590.618	169314.3	60	$5p^3\ ^2P_{3/2}$ - $5p^26d\ (^1D)\ ^2S_{1/2}$	0.002
590.698	169291.3	75	$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^3P)\ ^4D_{5/2}$	0.001
591.246	169134.4	60	$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^4D_{1/2}$	-0.003
591.634	169023.5	75	$5p^3\ ^2P_{3/2}$ - $5p^26d\ (^1D)\ ^2P_{3/2}$	0.005
592.343	168821.0	70	$5p^3\ ^2D_{5/2}$ - $5p^27s\ (^3P)\ ^4P_{5/2}$	0.003
592.385	168809.1	75	$5p^3\ ^2P_{3/2}$ - $5p^26d\ (^1D)\ ^2D_{5/2}$	-0.002
592.613	168744.1	35	$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^4F_{5/2}$	0.001
592.793	168692.9	55	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^4D_{7/2}$	0.000
593.392	168522.6	75	$5p^3\ ^2P_{3/2}$ - $5p^27d\ (^3P)\ ^4F_{3/2}$	0.000
593.841	168395.3	5	$5p^3\ ^2D_{3/2}$ - $5p^26d\ (^3P)\ ^2P_{3/2}$	0.003
593.890	168381.4	75	$5p^3\ ^2D_{3/2}$ - $5p^27s\ (^3P)\ ^2P_{1/2}$	-0.003
595.593	167900.0	60	$5p^3\ ^2D_{3/2}$ - $5p^27s\ (^3P)\ ^4P_{3/2}$	-0.002
596.137	167746.6	5	$5p^3\ ^2P_{3/2}$ - $5p^28s\ (^3P)\ ^4P_{1/2}$	0.002
598.011	167221.0	45	$5p^3\ ^2P_{3/2}$ - $5p^26d\ (^1D)\ ^2P_{1/2}$	0.002
598.139	167185.2	65	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^4D_{3/2}$	0.001
599.313	166857.7	60	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^2F_{5/2}$	0.000
602.637	165937.5	70	$5p^3\ ^2P_{3/2}$ - $5p^27s\ (^1D)\ ^2D_{3/2}$	-0.003
603.925	165583.4	40	$5p^3\ ^2P_{3/2}$ - $5p^27s\ (^1D)\ ^2D_{5/2}$	0.003
604.031	165554.4	40	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^4F_{5/2}$	-0.002
604.607	165396.8	70	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^4F_{7/2}$	0.000
605.306	165205.6	65	$5p^3\ ^2D_{5/2}$ - $5p^26d\ (^3P)\ ^2P_{3/2}$	0.000
607.130	164709.3	60	$5p^3\ ^2D_{5/2}$ - $5p^27s\ (^3P)\ ^4P_{3/2}$	-0.001
613.958	162877.6	75	$5p^3\ ^2P_{1/2}$ - $5p^26d\ (^3P)\ ^2D_{3/2}$	0.006

614.126	162833.0	72		$5p^3\ ^2D_{3/2} - 5p^26d\ (^3P)\ ^4P_{5/2}$	0.003
615.406	162494.4	70		$5p^3\ ^2P_{1/2} - 5p^26d\ (^3P)\ ^2P_{1/2}$	0.000
618.062	161796.0	65		$5p^3\ ^2D_{3/2} - 5p^26d\ (^3P)\ ^4F_{3/2}$	0.003
619.608	161392.3	65		$5p^3\ ^2D_{3/2} - 5p^27s\ (^3P)\ ^4P_{1/2}$	0.002
620.063	161274.0	45	W	$5p^3\ ^2P_{1/2} - 5p^26d\ (^3P)\ ^4P_{1/2}$	0.004
620.898	161057.0	15		$5p^3\ ^2P_{1/2} - 5p^26d\ (^3P)\ ^4P_{3/2}$	0.000
624.047	160244.4	75		$5p^3\ ^2P_{1/2} - 5p^27s\ (^3P)\ ^2P_{3/2}$	0.000
630.491	158606.6	35		$5p^3\ ^2D_{5/2} - 5p^26d\ (^3P)\ ^4F_{3/2}$	-0.001
633.761	157788.2	60		$5p^3\ ^2P_{1/2} - 5p^26d\ (^3P)\ ^4D_{3/2}$	-0.002
634.747	157543.2	25		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^2D_{3/2}$	-0.008
637.386	156890.8	65		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^2D_{5/2}$	0.000
638.792	156545.5	45		$5p^3\ ^2P_{1/2} - 5p^26d\ (^3P)\ ^4D_{1/2}$	0.000
641.810	155809.4	60	B	$5p^3\ ^2P_{1/2} - 5p^26d\ (^3P)\ ^2P_{3/2}$	-0.006
641.882	155791.9	66	B	$5p^3\ ^2P_{1/2} - 5p^27s\ (^3P)\ ^2P_{1/2}$	0.002
642.183	155718.8	15		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^4P_{3/2}$	0.002
643.534	155391.9	20		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^4D_{5/2}$	-0.002
645.549	154907.0	60		$5p^3\ ^2P_{3/2} - 5p^27s\ (^3P)\ ^2P_{3/2}$	-0.002
661.343	151207.4	45		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^4D_{1/2}$	0.002
663.051	150817.9	10		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^4F_{5/2}$	0.002
664.586	150469.6	35		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^2P_{3/2}$	0.002
670.206	149207.8	30		$5p^3\ ^2P_{1/2} - 5p^26d\ (^3P)\ ^4F_{3/2}$	0.003
672.019	148805.4	20		$5p^3\ ^2P_{1/2} - 5p^27s\ (^3P)\ ^4P_{1/2}$	-0.004
673.915	148386.6	2		$5p^3\ ^4S_{3/2} - 5p^25d\ (^1D)\ ^2D_{5/2}$	0.001
683.384	146330.6	35		$5p^3\ ^2D_{3/2} - 5p^25d\ (^1D)\ ^2S_{1/2}$	-0.001
690.087	144909.2	20		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^4P_{5/2}$	-0.006
693.595	144176.4	2		$5p^3\ ^4S_{3/2} - 5p^25d\ (^3P)\ ^2F_{5/2}$	0.002
695.062	143872.0	15		$5p^3\ ^2P_{3/2} - 5p^26d\ (^3P)\ ^4F_{3/2}$	-0.006
695.825	143714.2	40		$5p^3\ ^2D_{3/2} - 5p^25d\ (^1S)\ ^2D_{3/2}$	-0.004
703.119	142223.5	80	B	$5p^3\ ^4S_{3/2} - 5p^25d\ (^1D)\ ^2P_{1/2}$	0.000
709.252	140993.6	54		$5p^3\ ^2D_{3/2} - 5p^26s\ (^1S)\ ^2S_{1/2}$	-0.002
711.632	140522.1	4		$5p^3\ ^2D_{5/2} - 5p^25d\ (^1S)\ ^2D_{3/2}$	0.004
713.753	140104.4	45		$5p^3\ ^4S_{3/2} - 5s5p^4\ (^3P)\ ^2P_{3/2}$	0.003

716.886	139492.2	5		$5p^3\ ^2D_{3/2}$ - $5p^25d$ (^1D) $^2P_{3/2}$	-0.004
719.532	138979.2	75		$5p^3\ ^4S_{3/2}$ - $5p^26s$ (^1D) $^2D_{3/2}$	0.000
730.688	136857.3	10		$5p^3\ ^4S_{3/2}$ - $5p^26s$ (^1D) $^2D_{5/2}$	-0.002
733.666	136301.8	30		$5p^3\ ^2D_{5/2}$ - $5p^25d$ (^1D) $^2P_{3/2}$	-0.005
735.865	135894.5	45		$5p^3\ ^2D_{3/2}$ - 5s5p4 (^3P) $^2P_{1/2}$	0.005
742.351	134707.2	30		$5p^3\ ^4S_{3/2}$ - $5p^25d$ (^3P) $^2D_{3/2}$	-0.005
743.827	134439.8	55		$5p^3\ ^2D_{3/2}$ - $5p^25d$ (^1D) $^2D_{3/2}$	-0.003
748.169	133659.6	65		$5p^3\ ^4S_{3/2}$ - $5p^25d$ (^3P) $^4P_{1/2}$	0.001
749.146	133485.3	50		$5p^3\ ^2D_{5/2}$ - $5p^25d$ (^1D) $^2D_{5/2}$	0.002
753.933	132637.7	68		$5p^3\ ^4S_{3/2}$ - $5p^25d$ (^3P) $^4P_{3/2}$	0.001
754.913	132465.6	60		$5p^3\ ^2D_{3/2}$ - $5p^25d$ (^3P) $^2F_{5/2}$	0.004
761.913	131248.6	50		$5p^3\ ^2D_{5/2}$ - $5p^25d$ (^1D) $^2D_{3/2}$	0.001
762.630	131125.1	50		$5p^3\ ^2P_{1/2}$ - $5p^25d$ (^1S) $^2D_{3/2}$	0.000
765.614	130614.1	68		$5p^3\ ^4S_{3/2}$ - $5p^25d$ (^3P) $^4P_{5/2}$	0.003
766.213	130512.0	50		$5p^3\ ^2D_{3/2}$ - $5p^25d$ (^1D) $^2P_{1/2}$	0.005
773.543	129275.3	60		$5p^3\ ^2D_{5/2}$ - $5p^25d$ (^3P) $^2F_{5/2}$	0.003
774.987	129034.5	68		$5p^3\ ^2D_{5/2}$ - $5p^25d$ (^3P) $^2F_{7/2}$	0.000
778.789	128404.5	80	D	$5p^3\ ^2P_{3/2}$ - $5p^25d$ (^1D) $^2S_{1/2}$	0.000
				$5p^3\ ^2P_{1/2}$ - $5p^26s$ (^1S) $^2S_{1/2}$	0.003
778.849	128394.6	25		$5p^3\ ^2D_{3/2}$ - $5s5p^4$ (^3P) $^2P_{3/2}$	-0.002
782.218	127841.6	50		$5p^3\ ^4S_{3/2}$ - $5p^26s$ (^3P) $^2P_{3/2}$	0.005
785.742	127268.3	60		$5p^3\ ^2D_{3/2}$ - $5p^26s$ (^1D) $^2D_{3/2}$	0.001
787.105	127047.8	16		$5p^3\ ^4S_{3/2}$ - $5s5p^4$ (^1S) $^2S_{1/2}$	-0.004
788.007	126902.4	48		$5p^3\ ^2P_{1/2}$ - $5p^25d$ (^1D) $^2P_{3/2}$	0.005
792.170	126235.6	65		$5p^3\ ^4S_{3/2}$ - $5p^26s$ (^3P) $^4P_{5/2}$	0.005
794.993	125787.3	35		$5p^3\ ^2P_{3/2}$ - $5p^25d$ (^1S) $^2D_{3/2}$	0.001
798.488	125236.7	60		$5p^3\ ^2P_{3/2}$ - $5p^25d$ (^1S) $^2D_{5/2}$	0.000
798.696	125204.1	60		$5p^3\ ^2D_{5/2}$ - $5s5p^4$ (^3P) $^2P_{3/2}$	-0.002
799.069	125145.6	62		$5p^3\ ^2D_{3/2}$ - $5p^26s$ (^1D) $^2D_{5/2}$	0.004
801.792	124720.6	15		$5p^3\ ^4S_{3/2}$ - $5p^26s$ (^3P) $^2P_{1/2}$	0.005
805.944	124078.1	62		$5p^3\ ^2D_{5/2}$ - $5p^26s$ (^1D) $^2D_{3/2}$	0.000
809.194	123579.7	60		$5p^3\ ^2D_{5/2}$ - $5p^25d$ (^3P) $^2D_{5/2}$	0.002

810.998	123304.9	58	$5p^3\ ^2P_{1/2}$ - $5s5p^4\ (^3P)\ ^2P_{1/2}$	0.003
812.562	123067.5	55	$5p^3\ ^2P_{3/2}$ - $5p^26s\ (^1S)\ ^2S_{1/2}$	-0.001
813.042	122994.9	45	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^2D_{3/2}$	0.005
816.735	122438.8	60	$5p^3\ ^4S_{3/2}$ - $5p^26s\ (^3P)\ ^4P_{3/2}$	0.003
820.013	121949.3	44	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4P_{1/2}$	-0.001
820.678	121850.5	40	$5p^3\ ^2P_{1/2}$ - $5p^25d\ (^1D)\ ^2D_{3/2}$	0.004
822.604	121565.2	55	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^1D)\ ^2P_{3/2}$	0.002
823.855	121380.6	60	$5p^3\ ^4S_{3/2}$ - $5p^25d\ (^3P)\ ^4D_{5/2}$	-0.001
826.947	120926.7	9	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4P_{3/2}$	0.004
834.692	119804.6	52	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^2D_{3/2}$	0.004
835.301	119717.3	80	$5p^3\ ^4S_{3/2}$ - $5p^25d\ (^3P)\ ^4D_{3/2}$	0.004
835.777	119649.1	15	$5p^3\ ^4S_{3/2}$ - $5p^25d\ (^3P)\ ^4D_{1/2}$	0.001
841.011	118904.5	25	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4P_{5/2}$	-0.004
842.102	118750.5	60	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^1D)\ ^2D_{5/2}$	-0.002
847.691	117967.5	5	$5p^3\ ^2P_{3/2}$ - $5s5p^4\ (^3P)\ ^2P_{1/2}$	0.001
847.992	117925.6	35	$5p^3\ ^2P_{1/2}$ - $5p^25d\ (^1D)\ ^2P_{1/2}$	-0.007
849.346	117737.7	50	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^4P_{3/2}$	-0.007
857.627	116600.8	62	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^1D)\ ^2G_{7/2}$	0.000
857.950	116556.9	65	$5p^3\ ^4S_{3/2}$ - $5p^26s\ (^3P)\ ^4P_{1/2}$	-0.001
858.270	116513.5	38	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^1D)\ ^2D_{3/2}$	-0.001
861.094	116131.4	65	$5p^3\ ^2D_{3/2}$ - $5p^26s\ (^3P)\ ^2P_{3/2}$	0.003
861.102	116130.3	65	$5p^3\ ^4S_{3/2}$ - $5p^25d\ (^1D)\ ^2F_{5/2}$	-0.006
863.512	115806.1	40	$5p^3\ ^2P_{1/2}$ - $5s5p^4\ (^3P)\ ^2P_{3/2}$	0.000
864.204	115713.4	60	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^4P_{5/2}$	0.001
867.024	115337.1	35	$5p^3\ ^2D_{3/2}$ - $5s5p^4\ (^1S)\ ^2S_{1/2}$	-0.004
871.991	114680.1	35	$5p^3\ ^2P_{1/2}$ - $5p^26s\ (^1D)\ ^2D_{3/2}$	0.002
873.048	114541.2	10	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^3P)\ ^2F_{5/2}$	-0.006
873.161	114526.4	9	$5p^3\ ^2D_{3/2}$ - $5p^26s\ (^3P)\ ^4P_{5/2}$	-0.005
882.432	113323.2	38	$5p^3\ ^4S_{3/2}$ - $5p^25d\ (^3P)\ ^2P_{1/2}$	-0.007
884.877	113010.0	65	$5p^3\ ^2D_{3/2}$ - $5p^26s\ (^3P)\ ^2P_{1/2}$	0.006
885.414	112941.5	85	$5p^3\ ^2D_{5/2}$ - $5p^26s\ (^3P)\ ^2P_{3/2}$	-0.002
888.205	112586.6	30	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^1D)\ ^2P_{1/2}$	0.003
893.061	111974.4	60	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^4D_{7/2}$	0.000

894.402	111806.5	62	$5p^3\ ^4S_{3/2}$ - $5p^25d\ (^3P)\ ^4F_{5/2}$	-0.003
898.189	111335.2	60	$5p^3\ ^2D_{5/2}$ - $5p^26s\ (^3P)\ ^4P_{5/2}$	0.001
903.110	110728.5	50	$5p^3\ ^2D_{3/2}$ - $5p^26s\ (^3P)\ ^4P_{3/2}$	0.001
905.237	110468.3	20	$5p^3\ ^2P_{3/2}$ - $5s5p^4\ (^3P)\ ^2P_{3/2}$	0.001
905.736	110407.5	55	$5p^3\ ^2P_{1/2}$ - $5p^25d\ (^3P)\ ^2D_{3/2}$	0.000
908.012	110130.7	52	$5p^3\ ^4S_{3/2}$ - $5p^25d\ (^3P)\ ^4F_{3/2}$	-0.005
911.826	109670.0	52	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4D_{5/2}$	-0.001
914.554	109342.9	45	$5p^3\ ^2P_{3/2}$ - $5p^26s\ (^1D)\ ^2D_{3/2}$	-0.002
918.740	108844.7	12	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^3P)\ ^2D_{5/2}$	-0.001
925.861	108007.6	65	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4D_{3/2}$	-0.003
926.447	107939.2	25	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4D_{1/2}$	-0.005
929.896	107538.9	42	$5p^3\ ^2D_{5/2}$ - $5p^26s\ (^3P)\ ^4P_{3/2}$	-0.007
932.657	107220.6	3	$5p^3\ ^2P_{3/2}$ - $5p^26s\ (^1D)\ ^2D_{5/2}$	-0.002
937.917	106619.2	38	$5p^3\ ^4S_{3/2}$ - $5s5p^4\ (^1D)\ ^2D_{5/2}$	-0.003
939.150	106479.3	50	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^4D_{5/2}$	0.001
951.744	105070.3	25	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^3P)\ ^2D_{3/2}$	-0.004
953.787	104845.2	60	$5p^3\ ^2D_{3/2}$ - $5p^26s\ (^3P)\ ^4P_{1/2}$	0.009
954.046	104816.8	26	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^4D_{3/2}$	0.000
957.686	104418.4	50	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^1D)\ ^2F_{5/2}$	0.005
964.131	103720.3	30	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^1D)\ ^2F_{7/2}$	0.000
965.777	103543.6	22	$5p^3\ ^2P_{1/2}$ - $5p^26s\ (^3P)\ ^2P_{3/2}$	0.000
970.863	103001.1	6	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^3P)\ ^4P_{3/2}$	0.002
973.256	102747.9	55	$5p^3\ ^2P_{1/2}$ - $5s5p^4\ (^1S)\ ^2S_{1/2}$	0.005
984.143	101611.2	3	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^2P_{1/2}$	0.005
994.722	100530.6	55	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^4F_{7/2}$	0.000
995.785	100423.3	62	$5p^3\ ^2P_{1/2}$ - $5p^26s\ (^3P)\ ^2P_{1/2}$	-0.007
999.037	100096.4	58	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4F_{5/2}$	-0.008
1003.459	99655.3	50	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^2P_{3/2}$	-0.007
1016.056	98419.8	55	$5p^3\ ^2D_{3/2}$ - $5p^25d\ (^3P)\ ^4F_{3/2}$	-0.003
1018.266	98206.2	30	$5p^3\ ^2P_{3/2}$ - $5p^26s\ (^3P)\ ^2P_{3/2}$	-0.003
1026.582	97410.6	1	$5p^3\ ^2P_{3/2}$ - $5s5p^4\ (^1S)\ ^2S_{1/2}$	0.001
1031.946	96904.3	10	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^4F_{5/2}$	0.008
1036.662	96463.5	12	$5p^3\ ^2D_{5/2}$ - $5p^25d\ (^3P)\ ^2P_{3/2}$	0.007

1048.767	95350.1	3	$5p^3\ ^2P_{1/2}$ - $5p^25d\ (^3P)\ ^4D_{1/2}$	0.004
1053.650	94908.2	10	$5p^3\ ^2D_{3/2}$ - $5s5p^4\ (^1D)\ ^2D_{5/2}$	0.000
1076.395	92902.7	60	$5p^3\ ^4S_{3/2}$ - $5s5p^4\ (^3P)\ ^4P_{1/2}$	-0.006
1077.558	92802.4	15	$5p^3\ ^2P_{3/2}$ - $5p^26s\ (^3P)\ ^4P_{3/2}$	0.003
1089.811	91759.0	55	$5p^3\ ^2D_{3/2}$ - $5s5p^4\ (^1D)\ ^2D_{3/2}$	0.008
1090.313	91716.8	55	$5p^3\ ^2D_{5/2}$ - $5s5p^4\ (^1D)\ ^2D_{5/2}$	0.011
1099.347	90963.1	60	$5p^3\ ^4S_{3/2}$ - $5s5p^4\ (^3P)\ ^4P_{3/2}$	0.005
1123.298	89023.6	20	$5p^3\ ^2P_{1/2}$ - $5p^25d\ (^3P)\ ^2P_{1/2}$	0.000
1129.054	88569.7	14	$5p^3\ ^2D_{5/2}$ - $5s5p^4\ (^1D)\ ^2D_{3/2}$	-0.007
1150.474	86920.7	2	$5p^3\ ^2P_{3/2}$ - $5p^26s\ (^3P)\ ^4P_{1/2}$	-0.006
1165.080	85831.0	16	$5p^3\ ^2P_{1/2}$ - $5p^25d\ (^3P)\ ^4F_{3/2}$	0.005
1168.843	85554.7	65	$5p^3\ ^4S_{3/2}$ - $5s^5p4\ (^3P)\ ^4P_{5/2}$	0.003
1216.995	82169.6	6	$5p^3\ ^2P_{3/2}$ - $5p^25d\ (^3P)\ ^4F_{5/2}$	0.001
1261.782	79253.0	5	$5p^3\ ^2D_{3/2}$ - $5s5p^4\ (^3P)\ ^4P_{3/2}$	-0.001
1263.081	79171.5	2	$5p^3\ ^2P_{1/2}$ - $5s5p^4\ (^1D)\ ^2D_{3/2}$	0.000
1298.993	76982.7	32	$5p^3\ ^2P_{3/2}$ - $5s5p^4\ (^1D)\ ^2D_{5/2}$	-0.006
1314.700	76063.0	28	$5p^3\ ^2D_{5/2}$ - $5s5p^4\ (^3P)\ ^4P_{3/2}$	-0.009
1354.202	73844.2	40	$5p^3\ ^2D_{3/2}$ - $5s5p^4\ (^3P)\ ^4P_{5/2}$	0.002
1415.348	70654.0	60	$5p^3\ ^2D_{5/2}$ - $5s5p^4\ (^3P)\ ^4P_{5/2}$	-0.004
1457.647	68603.7	10	$5p^3\ ^2P_{1/2}$ - $5s5p^4\ (^3P)\ ^4P_{1/2}$	-0.005
1580.643	63265.4	6	$5p^3\ ^2P_{3/2}$ - $5s5p^4\ (^3P)\ ^4P_{1/2}$	0.007
1630.606	61326.9	16	$5p^3\ ^2P_{3/2}$ - $5s5p^4\ (^3P)\ ^4P_{3/2}$	0.004

† : Intensity is the relative visual estimates of the photographic blackening on the plate in the scale of 1-100.

⋆ : B – Blended with other line of iodine; W – wide line; D – doubly classified line

a : diff. ($\Delta\lambda$) = Observed λ – calculated λ from levels in Table 3.2 & 3.4

Table 3.2. Observed and Least Squares Fitted (LSF) energy levels (in cm^{-1}) of ground configuration of I III

J	E(obs)	E(LSF)	diff.	LS-composition
1/2	24298.8	24300.0	-1.2	100% ^2P
3/2	0.0	0.0	0.0	89% ^4S + 9% ^2P
	11710.6	11706.0	4.6	78% ^2D + 15% ^2P + 7% ^4S
	29636.6	29635.0	1.6	76% ^2P + 19% ^2D + 4% ^4S
5/2	14901.0	14906.0	-5.0	100% ^2D

Table 3.3. Least Squares Fitted energy parameters (in cm^{-1}) of ground configuration of I III

Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$5s^2 5p^3$	E_{av} $(5s^2 5p^3)$	15170	2	16194	
	$F^2(5p, 5p)$	37309	15	48552	0.768
	α_{5p}	-110	(fixed)		
	ζ_{5p}	6633	4	6271	1.058
	σ	5			

$$\sigma = \left[\frac{\Sigma(obs.value - cal.value)^2}{n-m}\right]^{1/2}$$

Where n= number of the known levels and m= number of the free parameters.

E_{av} is the average configuration energy with respect to the E_{av} of ground configuration.

Table 3.4. Observed and least squares fitted energy levels (in cm^{-1}) for excited configurations of I III

J	E(obs)	E(LSF)	diff.	LS-composition.
1/2	92902.2	92916	-13.8	82% 5s 5p^4 (P)^{4}P + 13% 5s^2 5p^2 5d (^{3}P)^{4}P
	113322.4	113318	4.4	48% 5s^2 5p^2 5d (^{3}P)^{2}P + 15% 5s 5p^4 (^{3}P)^{2}P
				+ 14% 5s^2 5p^2 5d (^{3}P)^{4}D + 9% 5s^2 5p^2 6s (^{3}P)^{2}P
	116556.8	116521	36.8	68% 5s^2 5p^2 6s (^{3}P)^{4}P + 10% 5s^2 5p^2 5d (^{3}P)^{4}D
				+ 9% 5s^2 5p^2 6s (^{3}P)^{2}P + 7% 5s^2 5p^2 6s (^{1}S)^{2}S
	119649.2	119684	-34.8	71% 5s^2 5p^2 5d (^{3}P)^{4}D + 9% 5s^2 5p^2 5d (^{3}P)^{2}P
				+ 8% 5s^2 5p^2 6s (^{3}P)^{4}P + 5% 5s 5p^4 (^{3}P)^{2}P
	124721.3	124808	-86.7	62% 5s^2 5p^2 6s (^{3}P)^{2}P + 14% 5s 5p^4 (^{1}S)^{2}S
				+ 10% 5s^2 5p^2 6s (^{3}P)^{4}P + 8% 5s^2 5p^2 5d (^{1}D)^{2}S
	127047.2	126857	190.2	39% 5s 5p^4 (^{1}S)^{2}S + 21% 5s^2 5p^2 5d (^{1}D)^{2}S
				+ 15% 5s^2 5p^2 5d (^{3}P)^{2}P + 11% 5s^2 5p^2 6s (^{3}P)^{2}P
	133659.8	133776	-116.2	73% 5s^2 5p^2 5d (^{3}P)^{4}P + 11% 5s 5p^4 (P)^{4}P
				+ 8% 5s^2 5p^2 5d (^{1}D)^{2}P
	142223.5	141953	270.5	82% 5s^2 5p^2 5d (^{1}D)^{2}P + 9% 5s^2 5p^2 5d (^{3}P)^{4}P
	147604.2	148119	-514.8	43% 5s 5p^4 (^{3}P)^{2}P + 22% 5s^2 5p^2 5d (^{1}D)^{2}S
				+ 16% 5s^2 5p^2 5d (^{3}P)^{2}P + 7% 5s 5p^4 (^{1}S)^{2}S
	152703.8	152639	64.8	68% 5s^2 5p^2 6s (^{1}S)^{2}S + 15% 5s 5p^4 (^{3}P)^{2}P
				+ 5% 5s 5p^4 (^{1}S)^{2}S + 4% 5s^2 5p^2 6s (^{3}P)^{4}P
	158041.1	158172	-130.9	39% 5s^2 5p^2 5d (^{1}D)^{2}S + 21% 5s 5p^4 (^{1}S)^{2}S
				+ 17% 5s^2 5p^2 6s (^{1}S)^{2}S + 11% 5s 5p^4 (^{3}P)^{2}P
	173103.3	173112	-8.7	68% 5s^2 5p^2 7s (^{3}P)^{4}P + 23% 5s^2 5p^2 7s (^{3}P)^{2}P
				+ 8% 5s^2 5p^2 7s (^{1}S)^{2}S
	180092.0	180101	-9.0	50% 5s^2 5p^2 7s (^{3}P)^{2}P + 19% 5s^2 5p^2 6d (^{3}P)^{4}D
				+ 19% 5s^2 5p^2 7s (^{3}P)^{4}P + 8% 5s^2 5p^2 6d (^{3}P)^{2}P
	180844.3	180836	8.3	61% 5s^2 5p^2 6d (^{3}P)^{4}D + 21% 5s^2 5p^2 7s (^{3}P)^{2}P
				+ 7% 5s^2 5p^2 7s (^{3}P)^{4}P + 6% 5s^2 5p^2 6d (^{3}P)^{2}P
	185573.9	185551	22.9	74% 5s^2 5p^2 6d (^{3}P)^{4}P + 13% 5s^2 5p^2 6d (^{1}D)^{2}S
				+ 7% 5s^2 5p^2 6d (^{1}D)^{2}P
	186793.2	186615	178.2	68% 5s^2 5p^2 6d (^{3}P)^{2}P + 11% 5s^2 5p^2 6d (^{3}P)^{4}D
				+ 10% 5s^2 5p^2 6d (^{1}D)^{2}P + 5% 5s^2 5p^2 6d (^{1}D)^{2}S
	196858.0	196776	82.0	75% 5s^2 5p^2 6d (^{1}D)^{2}P + 8% 5s^2 5p^2 6d (^{3}P)^{2}P
				+ 5% 5s^2 5p^2 6d (^{3}P)^{4}D + 4% 5s^2 5p^2 6d (^{3}P)^{4}P
	197383.7	197398	-14.3	62% 5s^2 5p^2 8s (^{3}P)^{4}P + 25% 5s^2 5p^2 8s (^{3}P)^{2}P
				+ 8% 5s^2 5p^2 8s (^{1}S)^{2}S
	198951.5	198974	-22.5	77% 5s^2 5p^2 6d (^{1}D)^{2}S + 14% 5s^2 5p^2 6d (^{3}P)^{4}P

				+ 5% $5s^2 5p^2 6d\ (^3P)^2P$
	204252.4	204261	-8.6	56% $5s^2 5p^2 8s\ (^3P)^2P$ + 24% $5s^2 5p^2 8s\ (^3P)^4P$
				+ 13% $5s^2 5p^2 7d\ (^3P)^4D$ + 5% $5s^2 5p^2 7d\ (^3P)^2P$
	204557.0	204641	-84.0	64% $5s^2 5p^2 7d\ (^3P)^4D$ + 13% $5s^2 5p^2 8s\ (^3P)^2P$
				+ 11% $5s^2 5p^2 7d\ (^3P)^2P$ + 6% $5s^2 5p^2 7d\ (^3P)^4P$
	209049.4	208985	64.4	73% $5s^2 5p^2 7d\ (^3P)^4P$ + 14% $5s^2 5p^2 7d\ (^1D)^2S$
				+ 7% $5s^2 5p^2 7d\ (^1D)^2P$ + 5% $5s^2 5p^2 7d\ (^3P)^4D$
	209508.4	209434	74.4	66% $5s^2 5p^2 7d\ (^3P)^2P$ + 13% $5s^2 5p^2 7d\ (^1D)^2P$
				+ 13% $5s^2 5p^2 7d\ (^3P)^4D$ + 6% $5s^2 5p^2 7d\ (^1D)^2S$
	210664.8	210664	0.8	90% $5s^2 5p^2 7s\ (^1S)^2S$ + 5% $5s^2 5p^2 7s\ (^3P)^4P$
	220066.2	220362	-295.8	79% $5s^2 5p^2 7d\ (^1D)^2P$ + 10% $5s^2 5p^2 7d\ (^3P)^2P$
				+ 6% $5s^2 5p^2 7d\ (^3P)^4D$ + 4% $5s^2 5p^2 7d\ (^3P)^4P$
	221167.5	221312	-144.5	78% $5s^2 5p^2 7d\ (^1D)^2S$ + 15% $5s^2 5p^2 7d\ (^3P)^4P$
				+ 5% $5s^2 5p^2 7d\ (^3P)^2P$
	235482.1	235481	1.1	92% $5s^2 5p^2 8s\ (^1S)^2S$ + 5% $5s^2 5p^2 8s\ (^3P)^4P$
3/2	90963.6	90896	67.6	83% $5s\ 5p^4\ (^3P)^4P$ + 13% $5s^2 5p^2 5d\ (^3P)^4P$
	103470.2	103699	-228.8	43% $5s\ 5p^4\ (^1D)^2D$ + 16% $5s^2 5p^2 5d\ (^1D)^2D$
				+ 14% $5s^2 5p^2 5d\ (^3P)^2P$ + 9% $5s^2 5p^2 5d\ (^3P)^4F$
	110130.1	110091	39.1	59% $5s^2 5p^2 5d\ (^3P)^4F$ + 17% $5s\ 5p^4\ (^1D)^2D$
				+ 11% $5s^2 5p^2 5d\ (^3P)^4D$ + 6% $5s^2 5p^2 5d\ (^1D)^2D$
	111365.2	111460	-94.8	48% $5s^2 5p^2 5d\ (^3P)^2P$ + 20% $5s^2 5p^2 5d\ (^3P)^4F$
				+ 13% $5s\ 5p^4\ (^3P)^2P$ + 7% $5s\ 5p^4\ (^1D)^2D$
	119717.8	119777	-59.2	80% $5s^2 5p^2 5d\ (^3P)^4D$ + 7% $5s^2 5p^2 5d\ (^3P)^4F$
	122439.2	122539	-99.8	93% $5s^2 5p^2 6s\ (^3P)^4P$ + 5% $5s^2 5p^2 6s\ (^3P)^2P$
	127842.4	127799	43.4	48% $5s^2 5p^2 6s\ (^3P)^2P$ + 33% $5s^2 5p^2 6s\ (^1D)^2D$
				+ 7% $5s^2 5p^2 5d\ (^1D)^2P$ + 4% $5s^2 5p^2 5d\ (^3P)^2D$
	132637.8	132524	113.8	67% $5s^2 5p^2 5d\ (^3P)^4P$ + 10% $5s\ 5p^4\ (^3P)^4P$
				+ 9% $5s^2 5p^2 5d\ (^1D)^2P$ + 7% $5s^2 5p^2 6s\ (D)^2D$
	134706.3	134484	222.3	51% $5s^2 5p^2 5d\ (^3P)^2D$ + 20% $5s^2 5p^2 6s\ (P)^2P$
				+ 17% $5s^2 5p^2 5d\ (^1S)^2D$
	138979.1	139192	-212.9	51% $5s^2 5p^2 6s\ (^1D)^2D$ + 17% $5s^2 5p^2 6s\ (^3P)^2P$
				+ 10% $5s^2 5p^2 5d\ (^3P)^2D$ + 7% $5s^2 5p^2 5d\ (^1D)^2P$
	140104.9	139710	394.9	48% $5s\ 5p^4\ (^3P)^2P$ + 31% $5s^2 5p^2 5d\ (^1D)^2P$
				+ 10% $5s^2 5p^2 5d\ (^1D)^2D$ + 4% $5s^2 5p^2 5d\ (^3P)^2P$
	146149.8	146208	-58.2	50% $5s^2 5p^2 5d\ (^1D)^2D$ + 16% $5s^2 5p^2 5d\ (^1D)^2P$
				+ 15% $5s\ 5p^4\ (^1D)^2D$ + 6% $5s^2 5p^2 6s\ (^1D)^2D$
	151202.0	151015	187.0	24% $5s\ 5p^4\ (^3P)^2P$ + 24% $5s^2 5p^2 5d\ (^1D)^2P$
				+ 23% $5s^2 5p^2 5d\ (^3P)^2P$ + 11% $5s^2 5p^2 5d\ (^1D)^2D$
	155423.9	155670	-246.1	68% $5s^2 5p^2 5d\ (^1S)^2D$ + 24% $5s^2 5p^2 5d\ (^3P)^2D$
	173507.3	173431	76.3	55% $5s^2 5p^2 6d\ (^3P)^4F$ + 15% $5s^2 5p^2 6d\ (^3P)^4D$
				+ 11% $5s^2 5p^2 6d\ (^3P)^2P$ + 9% $5s^2 5p^2 6d\ (^1S)^2D$

	179610.1	179620	-9.9	86% 5s^2 5p^2 7s (^{3}P)^{4}P + 11% 5s^2 5p^2 7s (^{3}P)^{2}P
	180106.6	180114	-7.4	35% 5s^2 5p^2 6d (^{3}P)^{4}F + 32% 5s^2 5p^2 6d (^{3}P)^{2}P
				+ 18% 5s^2 5p^2 6d (^{3}P)^{4}D + 11% 5s^2 5p^2 6d (^{3}P)^{4}P
	182086.4	182075	11.4	33% 5s^2 5p^2 6d (^{3}P)^{4}D + 27% 5s^2 5p^2 6d (^{3}P)^{2}P
				+ 16% 5s^2 5p^2 6d (^{3}P)^{4}P + 14% 5s^2 5p^2 6d (^{3}P)^{2}D
	184543.1	184538	5.1	57% 5s^2 5p^2 7s (^{3}P)^{2}P + 27% 5s^2 5p^2 7s (^{1}D)^{2}D
				+ 5% 5s^2 5p^2 7s (^{3}P)^{4}P
	185357.7	185277	80.7	48% 5s^2 5p^2 6d (^{3}P)^{4}P + 22% 5s^2 5p^2 6d (^{3}P)^{4}D
				+ 13% 5s^2 5p^2 6d (^{1}D)^{2}P + 8% 5s^2 5p^2 6d (^{1}D)^{2}D
	187177.8	187266	-88.2	56% 5s^2 5p^2 6d (^{3}P)^{2}D + 16% 5s^2 5p^2 6d (^{1}D)^{2}D
				+ 9% 5s^2 5p^2 6d (^{1}D)^{2}P + 8% 5s^2 5p^2 6d (^{3}P)^{2}P
	195573.1	195571	2.1	61% 5s^2 5p^2 7s (^{1}D)^{2}D + 23% 5s^2 5p^2 7s (^{3}P)^{2}P
				+ 4% 5s^2 5p^2 7s (^{3}P)^{4}P
	196721.3	196735	-13.7	63% 5s^2 5p^2 6d (^{1}D)^{2}D + 7% 5s^2 5p^2 7s (^{1}D)^{2}D
				+ 7% 5s^2 5p^2 6d (^{3}P)^{4}D + 5% 5s^2 5p^2 6d (^{3}P)^{4}P
	198159.1	198183	-23.9	41% 5s^2 5p^2 7d (^{3}P)^{4}F + 14% 5s^2 5p^2 7d (^{3}P)^{2}P
				+ 14% 5s^2 5p^2 7d (^{3}P)^{4}D + 8% 5s^2 5p^2 7d (^{3}P)^{2}D
	198661.3	198529	132.3	57% 5s^2 5p^2 6d (^{1}D)^{2}P + 8% 5s^2 5p^2 6d (^{3}P)^{2}P
				+ 8% 5s^2 5p^2 7d (^{3}P)^{4}F + 6% 5s^2 5p^2 6d (^{3}P)^{2}D
	204017.7	204019	-1.3	84% 5s^2 5p^2 8s (^{3}P)^{4}P + 14% 5s^2 5p^2 8s (^{3}P)^{2}P
	204372.0	204331	41.0	40% 5s^2 5p^2 7d (^{3}P)^{4}F + 32% 5s^2 5p^2 7d (^{3}P)^{2}P
				+ 13% 5s^2 5p^2 7d (^{3}P)^{4}D + 12% 5s^2 5p^2 7d (^{3}P)^{4}P
	205287.8	205265	22.8	32% 5s^2 5p^2 7d (^{3}P)^{4}D + 28% 5s^2 5p^2 7d (^{3}P)^{2}D
				+ 18% 5s^2 5p^2 7d (^{3}P)^{2}P + 17% 5s^2 5p^2 7d (^{3}P)^{4}P
	208476.8	208466	10.8	58% 5s^2 5p^2 8s (^{3}P)^{2}P + 28% 5s^2 5p^2 8s (D)^{2}D
				+ 8% 5s^2 5p^2 8s (^{3}P)^{4}P
	208936.1	208850	86.1	50% 5s^2 5p^2 7d (^{3}P)^{4}P + 19% 5s^2 5p^2 7d (^{3}P)^{4}D
				+ 18% 5s^2 5p^2 7d (^{1}D)^{2}P
	209418.9	209255	163.9	31% 5s^2 5p^2 7d (^{3}P)^{2}D + 19% 5s^2 5p^2 7d (^{3}P)^{2}P
				+ 17% 5s^2 5p^2 7d (^{1}D)^{2}D + 15% 5s^2 5p^2 6d (^{1}S)^{2}D
	211372.9	211630	-257.1	69% 5s^2 5p^2 6d (^{1}S)^{2}D + 12% 5s^2 5p^2 7d (^{3}P)^{2}D
				+ 5% 5s^2 5p^2 6d (^{3}P)^{2}D + 4% 5s^2 5p^2 7d (^{1}D)^{2}D
	219800.2	219818	-17.8	60% 5s^2 5p^2 8s (^{1}D)^{2}D + 21% 5s^2 5p^2 8s (^{3}P)^{2}P
				+ 8% 5s^2 5p^2 7d (^{1}D)^{2}D
	220416.3	220277	139.3	61% 5s^2 5p^2 7d (^{1}D)^{2}D + 11% 5s^2 5p^2 8s (^{1}D)^{2}D
				+ 7% 5s^2 5p^2 7d (^{3}P)^{4}D + 5% 5s^2 5p^2 7d (^{1}D)^{2}P
	221448.5	221093	355.5	69% 5s^2 5p^2 7d (^{1}D)^{2}P + 10% 5s^2 5p^2 7d (^{3}P)^{4}P
				+ 7% 5s^2 5p^2 7d (^{3}P)^{2}P + 7% 5s^2 5p^2 7d (^{3}P)^{2}D
	234965.5	235168	-202.5	92% 5s^2 5p^2 7d (^{1}S)^{2}D
5/2	85554.9	85621	-66.1	84% 5s 5p^4 (^{3}P)^{4}P + 11% 5s^2 5p^2 5d (^{3}P)^{4}P
	106619.3	106502	117.3	63% 5s 5p^4 (^{1}D)^{2}D + 24% 5s^2 5p^2 5d (^{1}D)^{2}D

111806.2	111760	46.2	70% $5s^2\ 5p^2\ 5d\ (^3P)^4F$ + 19% $5s^2\ 5p^2\ 5d\ (^3P)^4D$
116129.5	116205	-75.5	39% $5s^2\ 5p^2\ 5d\ (^1D)^2F$ + 34% $5s^2\ 5p^2\ 5d\ (^3P)^2F$
			+ 14% $5s^2\ 5p^2\ 5d\ (^3P)^4F$ + 11% $5s^2\ 5p^2\ 5d\ (^3P)^4D$
121380.5	121407	-26.5	56% $5s^2\ 5p^2\ 5d\ (^3P)^4D$ + 13% $5s^2\ 5p^2\ 5d\ (^3P)^2F$
			+ 10% $5s^2\ 5p^2\ 5d\ (^3P)^4F$ + 10% $5s^2\ 5p^2\ 5d\ (^1D)^2F$
126236.4	126194	42.4	71% $5s^2\ 5p^2\ 6s\ (^3P)^4P$ + 26% $5s^2\ 5p^2\ 6s\ (^1D)^2D$
130614.6	130454	160.6	72% $5s^2\ 5p^2\ 5d\ (^3P)^4P$ + 8% $5s^2\ 5p^2\ 5d\ (^3P)^4D$
			+ 8% $5s\ 5p^4\ (^3P)^4P$
136858.9	136582	276.9	35% $5s^2\ 5p^2\ 6s\ (^1D)^2D$ + 31% $5s^2\ 5p^2\ 5d\ (^3P)^2D$
			+ 19% $5s^2\ 5p^2\ 6s\ (^3P)^4P$ + 6% $5s^2\ 5p^2\ 5d\ (^3P)^2F$
138481.1	138550	-68.9	30% $5s^2\ 5p^2\ 6s\ (^1D)^2D$ + 24% $5s^2\ 5p^2\ 5d\ (^3P)^2D$
			+ 13% $5s^2\ 5p^2\ 5d\ (^1D)^2F$ + 13% $5s^2\ 5p^2\ 5d\ (^3P)^2F$
144176.9	144063	113.9	26% $5s^2\ 5p^2\ 5d\ (^1D)^2F$ + 18% $5s^2\ 5p^2\ 5d\ (^3P)^2F$
			+ 14% $5s^2\ 5p^2\ 5d\ (^1D)^2D$ + 13% $5s^2\ 5p^2\ 5d\ (^3P)^2D$
148386.7	148452	-65.3	48% $5s^2\ 5p^2\ 5d\ (^1D)^2D$ + 21% $5s^2\ 5p^2\ 5d\ (^1S)^2D$
			+ 11% $5s^2\ 5p^2\ 5d\ (^3P)^2D$ + 8% $5s\ 5p^4\ (^1D)^2D$
154873.3	154634	239.3	56% $5s^2\ 5p^2\ 5d\ (^1S)^2D$ + 14% $5s^2\ 5p^2\ 5d\ (^3P)^2D$
			+ 10% $5s^2\ 5p^2\ 5d\ (^3P)^2F$ + 5% $5s^2\ 5p^2\ 5d\ (^1D)^2F$
174544.5	174481	63.5	31% $5s^2\ 5p^2\ 6d\ (^3P)^4F$ + 27% $5s^2\ 5p^2\ 6d\ (^3P)^4D$
			+ 17% $5s^2\ 5p^2\ 6d\ (^3P)^4P$ + 14% $5s^2\ 5p^2\ 6d\ (^3P)^2F$
180454.9	180489	-34.1	56% $5s^2\ 5p^2\ 6d\ (^3P)^4F$ + 29% $5s^2\ 5p^2\ 6d\ (^3P)^4P$
			+ 6% $5s^2\ 5p^2\ 6d\ (^3P)^2D$
181758.7	181869	-110.3	64% $5s^2\ 5p^2\ 6d\ (^3P)^2F$ + 20% $5s^2\ 5p^2\ 6d\ (^3P)^4P$
			+ 8% $5s^2\ 5p^2\ 6d\ (^1D)^2F$
183723.0	183699	24.0	72% $5s^2\ 5p^2\ 7s\ (^3P)^4P$ + 26% $5s^2\ 5p^2\ 7s\ (^1D)^2D$
185027.9	184961	66.9	50% $5s^2\ 5p^2\ 6d\ (^3P)^4D$ + 19% $5s^2\ 5p^2\ 6d\ (^3P)^4P$
			+ 18% $5s^2\ 5p^2\ 6d\ (^1D)^2D$ + 5% $5s^2\ 5p^2\ 6d\ (^1D)^2F$
186527.2	186588	-60.8	56% $5s^2\ 5p^2\ 6d\ (^3P)^2D$ + 27% $5s^2\ 5p^2\ 6d\ (^1D)^2F$
			+ 10% $5s^2\ 5p^2\ 6d\ (^1D)^2D$
195220.4	195238	-17.6	67% $5s^2\ 5p^2\ 7s\ (^1D)^2D$ + 26% $5s^2\ 5p^2\ 7s\ (^3P)^4P$
			+ 4% $5s^2\ 5p^2\ 6d\ (^1D)^2D$
196268.5	196343	-74.5	32% $5s^2\ 5p^2\ 6d\ (^1D)^2F$ + 32% $5s^2\ 5p^2\ 6d\ (^1D)^2D$
			+ 11% $5s^2\ 5p^2\ 6d\ (^3P)^4D$ + 5% $5s^2\ 5p^2\ 6d\ (^3P)^4F$
198445.0	198280	165.0	32% $5s^2\ 5p^2\ 6d\ (^1D)^2D$ + 21% $5s^2\ 5p^2\ 6d\ (^3P)^2D$
			+ 14% $5s^2\ 5p^2\ 6d\ (^1D)^2F$ + 6% $5s^2\ 5p^2\ 7d\ (^3P)^2F$
198928.2	198891	37.2	23% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 19% $5s^2\ 5p^2\ 7d\ (^3P)^4F$
			+ 18% $5s^2\ 5p^2\ 7d\ (^3P)^4P$ + 11% $5s^2\ 5p^2\ 7d\ (^3P)^2F$
204634.5	204652	-17.5	56% $5s^2\ 5p^2\ 7d\ (^3P)^4F$ + 32% $5s^2\ 5p^2\ 7d\ (^3P)^4P$
			+ 9% $5s^2\ 5p^2\ 7d\ (^3P)^2D$
205227.6	205402	-174.4	64% $5s^2\ 5p^2\ 7d\ (^3P)^2F$ + 14% $5s^2\ 5p^2\ 7d\ (^3P)^4P$
			+ 7% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 7% $5s^2\ 5p^2\ 7d\ (^3P)^2D$
208114.9	208079	35.9	71% $5s^2\ 5p^2\ 8s\ (^3P)^4P$ + 27% $5s^2\ 5p^2\ 8s\ (^1D)^2D$

	208791.0	208715	76.0	47% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 21% $5s^2\ 5p^2\ 7d\ (^3P)^4P$ + 18% $5s^2\ 5p^2\ 7d\ (^1D)^2D$ + 6% $5s^2\ 5p^2\ 7d\ (^3P)^4F$
	209338.6	209336	2.6	47% $5s^2\ 5p^2\ 7d\ (^3P)^2D$ + 19% $5s^2\ 5p^2\ 7d\ (^1D)^2F$ + 16% $5s^2\ 5p^2\ 6d\ (^1S)^2D$ + 5% $5s^2\ 5p^2\ 7d\ (^1D)^2D$
	211256.6	211069	187.6	73% $5s^2\ 5p^2\ 6d\ (^1S)^2D$ + 9% $5s^2\ 5p^2\ 7d\ (^3P)^2D$ + 6% $5s^2\ 5p^2\ 7d\ (^1D)^2F$
	219657.0	219683	-26.0	65% $5s^2\ 5p^2\ 8s\ (^1D)^2D$ + 25% $5s^2\ 5p^2\ 8s\ (^3P)^4P$ + 6% $5s^2\ 5p^2\ 7d\ (^1D)^2D$
	220188.3	220147	41.3	35% $5s^2\ 5p^2\ 7d\ (^1D)^2F$ + 34% $5s^2\ 5p^2\ 7d\ (^1D)^2D$ + 11% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 5% $5s^2\ 5p^2\ 8s\ (^1D)^2D$
	220695.2	220951	-255.8	34% $5s^2\ 5p^2\ 7d\ (^1D)^2D$ + 32% $5s^2\ 5p^2\ 7d\ (^1D)^2F$ + 19% $5s^2\ 5p^2\ 7d\ (^3P)^2D$ + 6% $5s^2\ 5p^2\ 7d\ (^3P)^2F$
	235287.6	235083	204.6	92% $5s^2\ 5p^2\ 7d\ (^1S)^2D$
7/2	115431.6	115350	81.6	84% $5s^2\ 5p^2\ 5d\ (^3P)^4F$ + 14% $5s^2\ 5p^2\ 5d\ (^3P)^4D$
	118621.3	118649	-27.7	38% $5s^2\ 5p^2\ 5d\ (^3P)^4D$ + 33% $5s^2\ 5p^2\ 5d\ (^1D)^2F$ + 18% $5s^2\ 5p^2\ 5d\ (^3P)^2F$ + 7% $5s^2\ 5p^2\ 5d\ (^3P)^4F$
	126875.4	126949	-73.9	44% $5s^2\ 5p^2\ 5d\ (^3P)^4D$ + 23% $5s^2\ 5p^2\ 5d\ (^3P)^2F$ + 13% $5s^2\ 5p^2\ 5d\ (^1D)^2G$ + 12% $5s^2\ 5p^2\ 5d\ (^1D)^2F$
	131501.8	131599	-97.2	75% $5s^2\ 5p^2\ 5d\ (^1D)^2G$ + 20% $5s^2\ 5p^2\ 5d\ (^1D)^2F$
	143935.5	144266	-330.5	56% $5s^2\ 5p^2\ 5d\ (^3P)^2F$ + 33% $5s^2\ 5p^2\ 5d\ (^1D)^2F$ + 6% $5s^2\ 5p^2\ 5d\ (^1D)^2G$
	180297.8	180270	27.8	62% $5s^2\ 5p^2\ 6d\ (^3P)^4F$ + 30% $5s^2\ 5p^2\ 6d\ (^3P)^4D$ + 6% $5s^2\ 5p^2\ 6d\ (^3P)^2F$
	183593.9	183784	-190.1	32% $5s^2\ 5p^2\ 6d\ (^3P)^4D$ + 25% $5s^2\ 5p^2\ 6d\ (^3P)^4F$ + 20% $5s^2\ 5p^2\ 6d\ (^1D)^2F$ + 12% $5s^2\ 5p^2\ 6d\ (^3P)^2F$
	186788.0	186920	-132.0	51% $5s^2\ 5p^2\ 6d\ (^3P)^2F$ + 23% $5s^2\ 5p^2\ 6d\ (^1D)^2G$ + 17% $5s^2\ 5p^2\ 6d\ (^3P)^4D$ + 6% $5s^2\ 5p^2\ 6d\ (^1D)^2F$
	195065.7	195090	-24.3	59% $5s^2\ 5p^2\ 6d\ (^1D)^2F$ + 18% $5s^2\ 5p^2\ 6d\ (^3P)^4D$ + 14% $5s^2\ 5p^2\ 6d\ (^1D)^2G$ + 6% $5s^2\ 5p^2\ 6d\ (^3P)^2F$
	196672.5	196731	-58.5	53% $5s^2\ 5p^2\ 6d\ (^1D)^2G$ + 21% $5s^2\ 5p^2\ 6d\ (^3P)^2F$ + 13% $5s^2\ 5p^2\ 6d\ (^1D)^2F$ + 9% $5s^2\ 5p^2\ 6d\ (^3P)^4F$
	204610.0	204557	53.0	56% $5s^2\ 5p^2\ 7d\ (^3P)^4F$ + 34% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 10% $5s^2\ 5p^2\ 7d\ (^3P)^2F$
	208204.0	208354	-150.0	32% $5s^2\ 5p^2\ 7d\ (^3P)^4F$ + 32% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 16% $5s^2\ 5p^2\ 7d\ (^1D)^2F$ + 10% $5s^2\ 5p^2\ 7d\ (^3P)^2F$
	209621.7	209795	-173.3	56% $5s^2\ 5p^2\ 7d\ (^3P)^2F$ + 18% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 17% $5s^2\ 5p^2\ 7d\ (^1D)^2G$ + 8% $5s^2\ 5p^2\ 7d\ (^1D)^2F$
	219759.5	219615	144.5	64% $5s^2\ 5p^2\ 7d\ (^1D)^2F$ + 15% $5s^2\ 5p^2\ 7d\ (^3P)^4D$ + 12% $5s^2\ 5p^2\ 7d\ (^1D)^2G$ + 7% $5s^2\ 5p^2\ 7d\ (^3P)^2F$
	220318.4	220281	37.4	61% $5s^2\ 5p^2\ 7d\ (^1D)^2G$ + 15% $5s^2\ 5p^2\ 7d\ (^3P)^2F$ + 12% $5s^2\ 5p^2\ 7d\ (^1D)^2F$ + 9% $5s^2\ 5p^2\ 7d\ (^3P)^4F$

9/2	- 118795	-	87% $5s^2\ 5p^2\ 5d\ (^3P)\ ^4F$ + 13% $5s^2\ 5p^2\ 5d\ (^1D)\ ^2G$
	- 133521	-	87% $5s^2\ 5p^2\ 5d\ (^1D)\ ^2G$ + 13% $5s^2\ 5p^2\ 5d\ (^3P)\ ^4F$
	- 183898	-	76% $5s^2\ 5p^2\ 6d\ (^3P)\ ^4F$ + 24% $5s^2\ 5p^2\ 6d\ (^1D)\ ^2G$
	- 195976	-	76% $5s^2\ 5p^2\ 6d\ (^1D)\ ^2G$ + 24% $5s^2\ 5p^2\ 6d\ (^3P)\ ^4F$
	- 208389	-	77% $5s^2\ 5p^2\ 7d\ (^3P)\ ^4F$ + 23% $5s^2\ 5p^2\ 7d\ (^1D)\ ^2G$
	- 220014	-	77% $5s^2\ 5p^2\ 7d\ (^1D)\ ^2G$ + 23% $5s^2\ 5p^2\ 7d\ (^3P)\ ^4F$

Table 3.5. Least Squares Fitted energy parameters (in cm^{-1}) for excited configurations of I III

Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$5s\,5p^4$	$E_{av}(5s\,5p^4)$	114508	169	117350	0.982
	$F^2(5p, 5p)$	41420	928	48591	0.852
	α_{5p}	-349	-70		
	ζ_{5p}	6224	215	6252	0.996
	$G^1(5s, 5p)$	43557	348	64080	0.680
$5s^2\,5p^2\,6s$	$E_{av}(5s^2\,5p^2\,6s)$	131249	97	132461	0.998
	$F^2(5p, 5p)$	37372	840	50128	0.746
	α_{5p}	-250	-84		
	ζ_{5p}	7204	177	6806	1.058
	$G^1(5p, 6s)$	3840	290	5137	0.748
$5s^2\,5p^2\,7s$	$E_{av}(5s^2\,5p^2\,7s)$	188020	69	188624	1.002
	$F^2(5p, 5p)$	39157	808	50689	0.772
	α_{5p}	-184	-79		
	ζ_{5p}	7295	164	6931	1.052
	$G^1(5p, 7s)$	1207	267	1476	0.818
$5s^2\,5p^2\,8s$	$E_{av}(5s^2\,5p^2\,8s)$	212333	69	212558	1.004
	$F^2(5p, 5p)$	40199	788	50805	0.791
	α_{5p}	-228	-77		
	ζ_{5p}	7351	167	6962	1.056
	$G^1(5p, 8s)$	544	120	665	0.818
$5s^2\,5p^2\,5d$	$E_{av}(5s^2\,5p^2\,5d)$	129740	63	130859	0.999
	$F^2(5p, 5p)$	37431	465	49567	0.755
	α_{5p}	-92	-35		
	ζ_{5p}	6910	106	6612	1.045
	ζ_{5d}	286	(fixed)	286	1.000
	$F^2(5p, 5d)$	27327	469	32769	0.834
	$G^1(5p, 5d)$	25685	240	35747	0.719
	$G^3(5p, 5d)$	16148	487	22306	0.724
$5s^2\,5p^2\,6d$	$E_{av}(5s^2\,5p^2\,6d)$	188783	49	189623	1.001
	$F^2(5p, 5p)$	37945	489	50670	0.749
	α_{5p}	-98	-43		
	ζ_{5p}	7268	104	6910	0.611
	ζ_{6d}	94	(fixed)	94	1.000
	$F^2(5p, 6d)$	7139	431	9069	0.787
	$G^1(5p, 6d)$	4112	215	6729	0.611
	$G^3(5p, 5d)$	2793	146	4570	0.611
$5s^2\,5p^2\,7d$	$E_{av}(5s^2\,5p^2\,7d)$	212754	36	213282	1.003
	$F^2(5p, 5p)$	39902	453	50799	1.003
	α_{5p}	-84	-40		
	ζ_{5p}	6900	118	6954	0.992
	ζ_{7d}	45	(fixed)	45	1.000

	F^2(5p, 7d)	3121	35	3973	0.785
	G^1(5p, 7d)	1666	87	2725	0.611
	G^3(5p, 7d)	1165	61	1905	0.611
$5s\,5p^4$ $-5s^2\,5p^2\,6s$	R^1(5p, 5p; 5s, 6s)	-1068	-9	-1588	0.673
$5s\,5p^4$ $-5s^2\,5p^2\,7s$	R^1(5p, 5p; 5s, 7s)	-859	-7	-1277	0.673
$5s\,5p^4$ $-5s^2\,5p^2\,8s$	R^1(5p, 5p; 5s, 8s)	-734	(fixed)	-978	0.750
$5s\,5p^4$ $-5s^2\,5p^2\,5d$	R^1(5p, 5p; 5s, 5d)	30554	251	45415	0.673
$5s\,5p^4$ $-5s^2\,5p^2\,6d$	R^1(5p, 5p; 5s, 6d)	13441	111	19979	0.673
$5s\,5p^4$ $-5s^2\,5p^2\,7d$	R^1(5p, 5p; 5s, 7d)	8493	70	12624	0.673
$5s^2\,5p^2\,6s$ $-5s^2\,5p^2\,7s$	R^0(5p, 6s; 5p, 7s)	0			
	R^1(5p, 6s; 7s, 5p)	1781	15	2647	0.673
$5s^2\,5p^2\,6s$ $-5s^2\,5p^2\,8s$	R^0(5p, 6s; 5p, 8s)	0			
	R^1(5p, 6s; 8s, 5p)	1297	(fixed)	1730	0.750
$5s^2\,5p^2\,6s$ $-5s^2\,5p^2 5d$	R^2(5p, 6s; 5p, 5d)	-9795	-505	-12331	0.794
	R^1(5p, 6s; 5d, 5p)	-3957	-204	-4981	0.794
$5s^2\,5p^2\,6s$ $-5s^2\,5p^2\,6d$	R^2(5p, 6s; 5p, 6d)	1387	71	1746	0.794
	R^1(5p, 6s; 6d, 5p)	-495	-26	-623	0.794
$5s^2\,5p^2\,6s$ $-5s^2\,5p^2 7d$	R^2(5p, 6s; 5p, 7d)	1595	(fixed)	2127	0.750
	R^1(5p, 6s; 7d, 5p)	-60	(fixed)	-79	0.750
$5s^2\,5p^2\,7s$ $-5s^2\,5p^2\,8s$	R^0(5p, 7s; 5p, 8s)	0			
	R^1(5p, 7s; 8s, 5p)	740	(fixed)	987	0.750
$5s^2\,5p^2\,7s$ $-5s^2\,5p^2\,5d$	R^2(5p, 7s; 5p, 5d)	-4603	-237	-5794	0.794
	R^1(5p, 7s; 5d, 5p)	-2345	-121	-2952	0.794
$5s^2\,5p^2\,7s$ $-5s^2\,5p^2 6d$	R^0(5p, 5d; 5p, 6d)	-2512	-129	-3163	0.794
	R^1(5p, 8s; 6d, 5p)	-505	-26	-635	0.750
$5s^2\,5p^2\,7s$ $-5s^2\,5p^2\,7d$	R^2(5p, 8s; 5p, 7d)	-295	(fixed)	-394	0.750
	R^1(5p, 7s; 7d, 5p)	-185	(fixed)	-247	0.750
$5s^2\,5p^2\,8s$ $-5s^2\,5p^2 5d$	R^2(5p, 8s; 5p, 5d)	-2819	(fixed)	-3758	0.750
	R^1(5p, 8s; 5d, 5p)	-1535	(fixed)	-2047	0.750
$5s^2\,5p^2\,8s$ $-5s^2\,5p^2 6d$	R^2(5p, 8s; 5p, 6d)	-1459	(fixed)	-1945	0.750
	R^1(5p, 8s; 6d, 5p)	-374	(fixed)	-498	0.750
$5s^2\,5p^2\,8s$ $-5s^2\,5p^2 7d$	R^2(5p, 8s; 5p, 7d)	-957	(fixed)	-1276	0.750
	R^1(5p, 8s; 7d, 5p)	-163	(fixed)	-217	0.750
$5s^2\,5p^2\,5d$ $-5s^2\,5p^2 6d$	R^0(5p, 5d; 5p, 6d)	0			
	R^2(5p, 5d; 5p, 6d)	8584	442	10806	0.794
	R^1(5p, 5d; 6d, 5p)	11731	605	14768	0.794
	R^3(5p, 5d; 6d, 5p)	7594	391	9560	0.794
$5s^2\,5p^2\,5d$ $-5s^2\,5p^2 7d$	R^0(5p, 5d; 5p, 7d)	0			
	R^2(5p, 6d; 5p, 7d)	4673	(fixed)	6231	0.750
	R^1(5p, 5d; 7d, 5p	6838	(fixed)	9117	0.750
	R^3(5p, 5d; 7d, 5p)	4450	(fixed)	5934	0.750
$5s^2\,5p^2\,6d$ $-5s^2\,5p^2 7d$	R^0(5p, 6d; 5p, 7d)	0			
	R^2(5p, 6d; 5p, 7d)	3725	(fixed)	4966	0.750
	R^1(5p, 6d; 7d, 5p)	3199	(fixed)	4265	0.750
	R^3(5p, 6d; 7d, 5p)	2201	(fixed)	2935	0.750
	σ	170			

CHAPTER - 4

The Forth Spectrum of Iodine: I IV

4.1. Introduction:

The ground configuration of trebly ionized iodine is $5s^25p^2$ consisting of five energy levels namely $^3P_{0,1,2}$; $^1D_2$ and $^1S_0$. The three lowest odd parity configurations are $5s5p^3$, $5s^25p6s$ and $5s^25p5pd$. The first work on this spectrum was reported by Krishnamurty [1]. He classified 30 lines as transition between nine even and ten odd parity levels belonging to the $5s^25p6s$, $5s^25p5d$ and $5s^25p6p$ configurations in the wavelength region 1900 – 5000 Å using a condensed capillary discharge. He neither established any ground level nor any excited level.

The first reliable analysis of this spectrum was published by Tauheed, Joshi and Kaufman [2]. They established all five levels of the ground configuration $5s^25p^2$ and twenty-five levels of the three lowest excited configurations $5s5p^3$ + $5s^25p5d$ + $5s^25p6s$. They classified seventy-four lines in the wavelength region 627 - 1800 Å.

In the present work, the analysis of this ion has been extended considerably to include new configurations 5p6d, 5p7d, 5p7s, 5p8s and doubly exited configurations $5p^4$, $5s5p^2(5d + 6s)$, 5p5f, 5p7p, $6s^2$, 5d6s, 6s6d and $5d^2$. The detailed analysis will be discussed in the following sections.

4.2. The Term Structure of I IV :

Ground configuration : $5s^25p^2$: $^3P_{0,1,2}$ $^1D_2$, $^1S_0$

Excited configurations :

$5s\,5p^3$: $(^4S)\ ^5S_2$; $(^4S)\ ^3S_1$

$(^2D)\ ^3D_{1,2,3}$; $(^2D)\ ^1D_2$

$(^2P)\ ^3P_{0,1,2}$; $(^2P)\ ^1P_1$

$5s^2 5p$ nd : $^3P_{0,1,2}$; $^3D_{1,2,3}$; $^3F_{2,3,4}$; $^1P_1$, $^1D_2$, $^1F_3$

$5s^2 5p$ ns : $^3P_{0,1,2}$; $^1P_1$

$5s^2 5p$ np : $^3S_1$; $^3P_{0,1,2}$; $^3D_{1,2,3}$; $^1S_0$, $^1P_1$, $^1D_2$

$5s^2 5p$ nf : $^3D_{1,2,3}$; $^3F_{2,3,4}$; $^3G_{3,4,5}$; $^1D_2$, $^1F_3$, $^1G_4$

$5p^4$: $^3P_{2,1,0}$; $^1S_0$, $^1D_2$

$5s^2\,5d^2$: $^3P_{0,1,2}$; $^3F_{2,3,4}$; $^1G_4$; $^1D_2$; $^1S_0$

$5s^2\,6s^2$: $^1S_0$

$5s\,5p^2\,5d$:$((^3P),\,^4P)\ ^5P_{3,2,1}$; $^5D_{4,3,2,1,0}$; $^5F_{5,4,3,2,1,}$; $^3P_{2,1,0}$; $^3D_{3,2,1}$;

$^3F_{4,3,2}$

$((^3P),\,^2P)\ ^3P_{,2,1,0}$; $^3D_{3,2,1}$; $^3F_{4,3,2}$; $^1P_1$, $^1D_2$, $^1F_3$

$((^1D),\,^2D)\ ^3S_1$; $^3P_{2,1,0}$; $^3D_{3,2,1}$; $^3F_{4,3,2}$; $^3G_{5,4,3}$

$^1S_0$, $^1P_1$, $^1D_2$; $^1F_3$, $^1G_4$

$((^1S)\,^2S)\ ^3D_{3,2,1}$; $^1D_2$

$5s\,5p^2\ 6s$: $((^3P),\,^4P)\ ^5P_{3,2,1}$; $^3P_{2,1,0}$

$((^3P),\,^2P)\ ^3P_{2,1,0}$; $^1P_1$

$((^1D)\,^2D)\ ^3D_{3,2,1};\ ^1D_2$

$((^1S)\,^2S)\ ^3S_1;\ ^1S_0$

5d6s : $^3D_{1,2,3}$; $^1D_2$

6s6d : $^3D_{1,2,3}$; $^1D_2$

4.3. Results and discussion

The $5s^25p^2$ –[$5s5p^3 + 5s^25p(5d + 6s)$] array :

This array was analyzed by Tauheed, Joshi and Kaufman [2]. They published all the levels of $5s^25p^2$, $5s5p^3$, $5s^25p5d$ and $5s^25p6s$ configurations except 5p5d $^3F_4$ as this level dose not combine with any of the ground levels. In the present work we undertook this array as well as extended this work to higher excitation to include 5p6d, 5p7d, 5p7s and 5p8s configurations. Configuration interaction (C.I.) Hatree-Fock calculations with relativistic corrections were made including all the configurations mentioned above. After having reliable prediction, we started the verification of $5s^25p^2$- $5s5p^3 + 5s^25p(5d + 6s)$ transition array. All the levels reported in ref. [2] were found to be satisfactory and are therefore, confirmed in the present work. Seventy-four lines have been classified in this array. Majority of the levels show LS purity higher than 50% and can be assigned LS designation unambiguously. Two levels with J=1 (143392cm^{-1} and 146887 cm^{-1}) and the two levels with J = 2 (123187 cm^{-1} and 155919 cm^{-1}) need special mention. For J=1 level, one would like to designate the 146887 cm^{-1} level as 5p5d $^3D_1$ as this level contains 36% of that eigenvector. However, in that case the level at 143392 cm^{-1} has no choice left to be designated because all other components have already been designated well. Therefore, the leading component of 143392 cm^{-1}

was chosen as 5p5d $^3D_1$. The second largest component of 146887 cm^{-1} with 26% LS purity was assigned as $5s5p^3$ $^1P_1$ level. Though $5s5p^3$ $^1P_1$ has larger share with $5s5p^3$ $^3S_1$ but $5s5p^3$ $^3S_1$ is unambiguous and has LS purity 60%. Therefore, the only choice for $5s5p^3$ $^1P_1$ level remains is 146887 cm^{-1}. The level designation given also conforms to the configuration designation. In case of J = 2 level there is a tendency to assign the level at 123186 cm^{-1} as 5p5d $^1D_2$ and 155919 cm^{-1} as $5s5p^3$ $^1D_2$ because the largest eigenvector component would lead to these names. However, the designation in the Table 4.2 has been adopted to adhere to the total configuration contribution to each level. Consequently the level at 123187 cm^{-1} has been assigned as $5s5p^3$ $^1D_2$ and 155919 cm^{-1} level was given 5p5d $^1D_2$ designation.

The $5s^25p(6d + 7d + 7s + 8s)$ Configurations:

After completion of $5s^25p^2 - 5s5p^3 + 5s^25p(5d + 6s)$ transition array, next array $5s^25p^2 - 5s^25p(6d + 7d + 7s + 8s)$ was undertaken. Applying the same parameter scaling for 5p6d, 5p7s configurations as 5p5d and 5p6s, level of these configurations were found satisfactorily. Three levels of J=4 (5p5d, 5p6d and 5p7d) could not be established as they do not combine with ground levels. It should be pointed out that seven levels are based on single transition each. Four of these seven levels are J=0 levels, give necessarily single permitted transition. The other three levels at 259670 cm^{-1} (J=2), 260878 cm^{-1} (J=1) and 272440 cm^{-1} (J=1) are $5s^25p7d$ $^3F_2$, $^3D_1$ and $^3P_1$ respectively and for all of them there is only one observable transition whereas the other transitions to the levels of the $5s^25p^2$ configuration have transition probabilities two orders of magnitude lower. In all these cases the lines have been checked carefully against the ionization character of the line. Seventy-six lines have been classified as

$5s^25p^3$ - $5s^25p(6d + 7d + 7s + 8s)$ transitions. Only one line is doubly classified in this array.

It should be pointed out that for $5s^25p6d$ configuration the parameter value of G^1, G^3 were fixed at 70% of their corresponding HFR values. If they are set free to vary in the iteration process then the fit improves slightly and the deviation of the 5p6d $^1F_3$ level improves but the scaling factor drops to 0.6. All levels of 5p6d were checked thoroughly and were found to be satisfactory. In 5p7d configuration G^1 and G^3 parameters were linked to vary in the same ratio. In order to find J=4 levels of the $5s^25pnd$ configurations one needs to study $5s^25p(6p + 4f)$ configurations. The transitions from these levels mostly lie in the wavelength region above 2000 Å which is beyond our region of present investigation. However, in near future we do expect to have spectrum in region 2000- 4000 Å then these configurations can be analyzed. All the levels of $5s^25p^2$, $5s5p^3$, 5p5d, 5p6d, 5p7d, 5p6s, 5p7s and 5p8s configurations have already been published in Physica Scripta [3]. It must be pointed out that $5s5p^3$ $^3D_3$ has been misprinted in this paper. The correct value is 102368.9 cm^{-1}.

Doubly excited configurations of I IV:

As mentioned in earlier section that the three lowest excited configurations of I IV are $5s5p^3$, $5s^25p5d$ and $5s^25p6s$. These configurations can be further excited to a number of configurations like $5s^25p4f$, $5s^25p5f$, $5s^25p6p$, $5s^25p7p$, $5p^4$, $5s5p^2(5d + 6s)$, $5s^25d^2$, $5s^26s^2$, $5s^25d6s$ and $5s^26s6d$. All these configurations were incorporated in the C.I calculations. As evident from Fig. 4.1 isoelectronic plot that 5p4f and 5p6p configurations are close to 5p6d and 5p6s configurations and transitions between them lie mostly above 2000 Å and is beyond our region of present

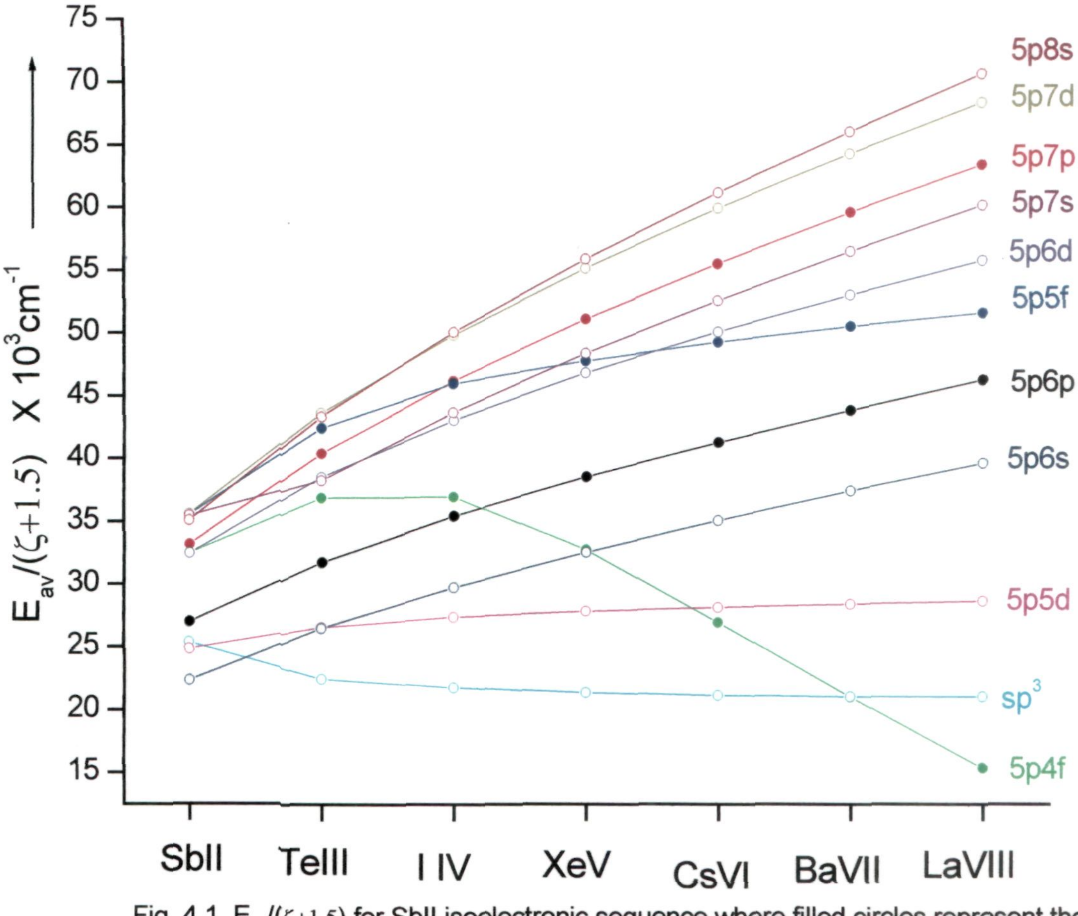


Fig. 4.1. $E_{av}/(\zeta+1.5)$ for SbII isoelectronic sequence where filled circles represent the even parity &hollow circles the odd parity configurations.

investigation. However, the remaining configurations do lie in our spectral wavelength region. Therefore, $5p^4$, $5s^25p5f$, $5s^25p7p$, $5s5p^2(5d+6s)$, $5s^26s^2$, $5s^25d^2$, $5s^25d6s$ and $5s^26s6d$ configurations have been analyzed. Though most of the transitions show weak transition probabilities, poses problem to the level identification. However lines with correct ionization character have been used to establish these levels. Only eleven levels are based on *single transition while rest of the levels are establish with supporting lines.* These levels are strongly mixed with each other and show poor LS purity. The configuration $5p^4$ needs special mention. There are five levels in $5p^4$ configuration namely $^3P_{0,1,2}$ $^1D_2$ and $^1S_0$. However, these levels are so strongly mixed with the levels of other configurations that none of them showed LS purity even close to 50%. Thus LS designation in such cases dose not mean much. However, over all situation of LS purity for remaining configurations is still not bad. About 66% levels have their main LS components 50% or greater. Consequently, nothing better is available to adopt LS designation to conform the earlier work.

The agreement with calculated values are in general quite good, the standard deviation of 119 even parity levels is only 193 cm^{-1}.Only seven levels deviate more than 300cm^{-1}. The standard deviation of the least squares fitted parametric calculation for odd parity is 148 cm^{-1}.

A total of **four hundred thirty four** (434) lines have been classified in I IV and they are given in Table 4.1.**One hundred seventy four** (174) levels have been established in I IV out of which **144** levels are new. The least squares fitted odd and even parity levels are given in Table 4.2 & 4.3 respectively. The energy parameters used for these calculations are given in Table 4.4 & 4.5 respectively. The energy spread of various odd and even parity configurations are shown in Fig.4.2 and Fig. 4.3 respectively.

4.4. Ionization limit of I IV:

Knowing three consecutive members of $5s^25pns$ (n=5, 6, 7) the series ionization limit of I IV can be calculated using Edlén's formula [4]. In doing so we choose only those members where mixing percentage did not change significantly from one member to the next. The calculated value of the limit is: $5s^25p\ ^2P_{1/2}$ (I V)= 325500 ± 200 cm^{-1} (40.35 ± 0.02eV).

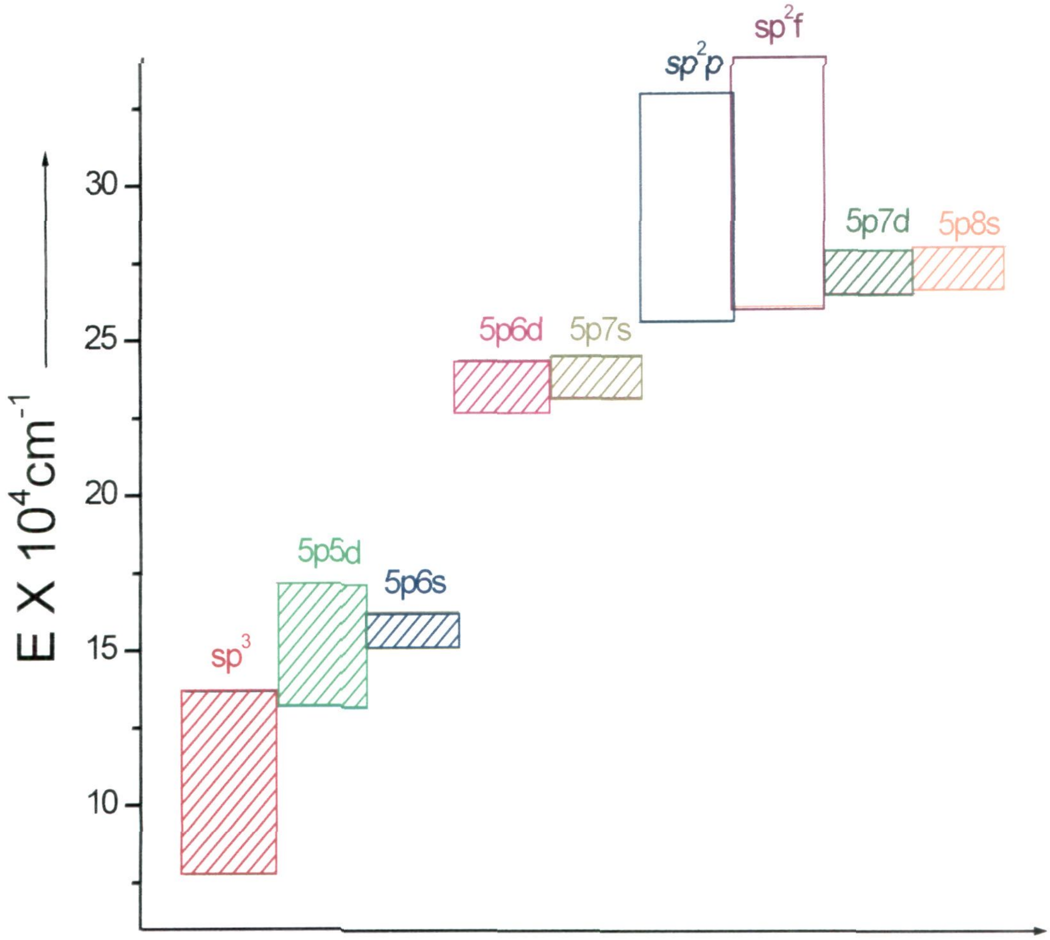


Fig. 4.2. Energy spread of various odd parity configuratin in I IV, filled rectangles represent analyzed configurations.

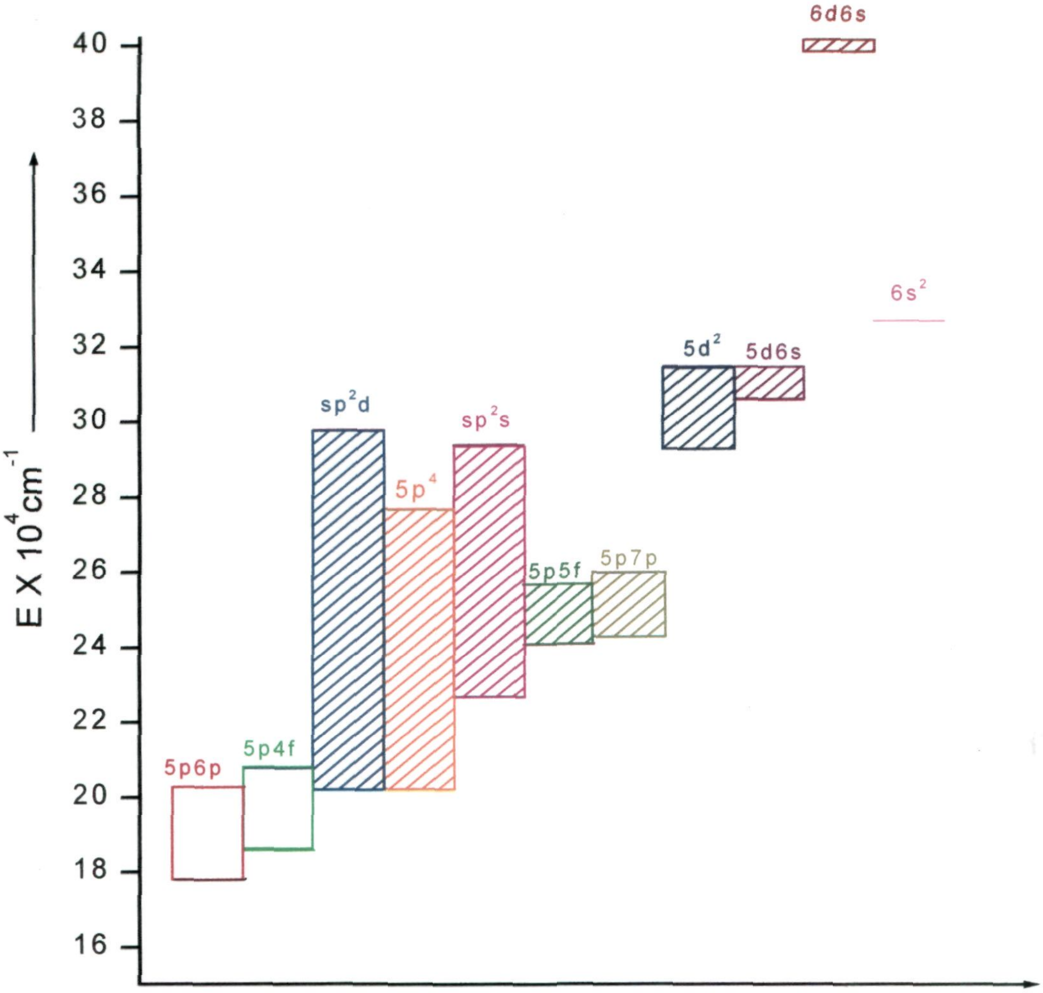


Fig. 4.3. Energy spread of various even parity configurations in I IV, filled rectangles represent analyzed configurations.

References:

1. Krishnamurty S.G. , Proc. Phys. Soc. **48**, 277 (1936).
2. A. Tauheed, Y.N. Joshi and V. Kaufman, "Analysis of the 5s25p2, 5s5p3, 5s25p5d and 5s25p6s configurations of I IV" J. Phys. B: At. Mol. Opt. Phys. **24** 3701 (1991).
3. A. Tauheed, Y. N. Joshi and Anjum Naz , Physica Scripta. **69**, 283 (2004).
4. B. Edlén " Atomic Spectra" in Handbuch der Physik Springer Verlag, Vol. **27**, 80-220 (1964).

Table 4.1. Classified lines of I IV spectrum

Wavelength λ(Å)	Wavenumber ν(cm^{-1})	Int	Ch[a]	Classification[b]	diff.[c] $\Delta\lambda$(Å)
364.214	274564.1	4		sp^2 $^3P_0$ - 8s $^1P_1$	-0.004
373.513	267728.2	5		sp^2 $^3P_1$ - 8s $^1P_1$	0.006
373.985	267390.6	20		sp^2 $^3P_1$ - 8s $^3P_2$	0.010
376.315	265734.9	12		sp^2 $^3P_1$ - 7d $^3P_0$	0.000
376.489	265612.2	20		sp^2 $^3P_1$ - 7d $^3P_1$	0.000
377.615	264819.9	22		sp^2 $^3P_1$ - 7d $^1D_2$	0.000
379.395	263577.7	6		sp^2 $^3P_2$ - 8s $^1P_1$	0.003
379.876	263243.8	65		sp^2 $^3P_2$ - 8s $^3P_2$	0.001
381.359	262220.1	10		sp^2 $^3P_0$ - 8s $^3P_1$	0.000
381.492	262129.0	5		sp^2 $^3P_2$ - 7d $^1F_3$	-0.002
382.368	261528.5	10		sp^2 $^3P_2$ - 7d $^3P_2$	0.001
383.051	261062.1	25		sp^2 $^3P_2$ - 7d $^3D_3$	0.000
383.321	260877.7	7		sp^2 $^3P_0$ - 7d $^3D_1$	0.000
383.632	260666.3	30		sp^2 $^3P_2$ - 7d $^1D_2$	0.001
391.555	255392.1	8		sp^2 $^3P_1$ - 8s $^3P_1$	0.000
391.778	255246.9	20		sp^2 $^3P_1$ - 8s $^3P_0$	0.000
394.610	253414.9	20		sp^2 $^3P_1$ - 7d $^3D_2$	0.000
396.777	252030.8	20		sp^2 $^1D_2$ - 8s $^1P_1$	-0.003
397.315	251689.6	10		sp^2 $^1D_2$ - 8s $^3P_2$	0.007
398.024	251241.2	35	D	sp^2 $^3P_2$ - 8s $^3P_1$	-0.004
				sp^2 $^1D_2$ - 7d $^1P_1$	0.004
399.081	250575.7	30		sp^2 $^1D_2$ - 7d $^1F_3$	0.002
399.227	250484.1	5		6s $^3P_1$ - 6s6d $^3D_2$	-0.001
400.033	249979.4	10		sp^2 $^1D_2$ - 7d $^3P_2$	-0.001
400.493	249692.4	25		sp^2 $^3P_2$ - 7d $^3F_3$	0.001
400.783	249511.8	4		sp^2 $^1D_2$ - 7d $^3D_3$	0.000
401.176	249267.0	4		sp^2 $^3P_2$ - 7d $^3D_2$	-0.009
401.417	249117.2	4		sp^2 $^1D_2$ - 7d $^1D_2$	-0.001

402.111	248687.6	10	$sp^2\ ^3P_2$ - 7d $^3F_2$	0.000
416.954	239834.5	7	$sp^2\ ^3P_0$ - 7s $^1P_1$	-0.002
417.211	239686.6	4	$sp^2\ ^1D_2$ - 8s $^3P_1$	0.003
419.915	238143.6	8	$sp^2\ ^1D_2$ - 7d $^3F_3$	-0.001
421.255	237386.1	15	$sp^2\ ^1S_0$ - 8s $^1P_1$	-0.004
422.654	236600.3	10	$sp^2\ ^1S_0$ - 7d $^1P_1$	-0.003
429.181	233002.0	11	$sp^2\ ^3P_1$ - 7s $^1P_1$	0.006
431.339	231836.2	60	$sp^2\ ^3P_1$ - 7s $^3P_2$	0.001
432.466	231232.2	5	$sp^2\ ^3P_1$ - 6d $^1P_1$	-0.004
435.669	229531.9	47	$sp^2\ ^3P_1$ - 6d $^3P_0$	0.000
436.851	228910.9	66	$sp^2\ ^3P_1$ - 6d $^3P_1$	0.000
436.958	228855.1	25	$sp^2\ ^3P_2$ - 7s $^1P_1$	-0.006
437.248	228703.4	5	$sp^2\ ^3P_1$ - 6d $^3D_2$	0.006
439.204	227684.6	70	$sp^2\ ^3P_2$ - 7s $^3P_2$	-0.002
440.380	227076.7	28	$sp^2\ ^3P_2$ - 6d $^1P_1$	0.001
440.691	226916.6	66	$sp^2\ ^3P_1$ - 6d $^1D_2$	-0.002
440.861	226828.9	69	$sp^2\ ^3P_0$ - 7s $^3P_1$	0.000
442.297	226092.4	60	$sp^2\ ^3P_2$ - 6d $^1F_3$	0.004
444.922	224758.7	39	$sp^2\ ^3P_2$ - 6d $^3P_1$	-0.002
445.326	224554.6	72	$sp^2\ ^3P_2$ - 6d $^3D_2$	-0.003
446.559	223934.6	73	$sp^2\ ^3P_0$ - 6d $^3D_1$	0.001
447.563	223432.3	78	$sp^2\ ^3P_2$ - 6d $^3D_3$	0.002
448.905	222764.1	70	$sp^2\ ^3P_2$ - 6d $^1D_2$	-0.003
454.544	220000.6	60	$sp^2\ ^3P_1$ - 7s $^3P_1$	0.000
455.153	219706.4	69	$sp^2\ ^3P_1$ - 7s $^3P_0$	0.000
460.191	217301.2	70	$sp^2\ ^1D_2$ - 7s $^1P_1$	0.001
460.602	217107.0	49	$sp^2\ ^3P_1$ - 6d $^3D_1$	0.000
461.714	216584.5	75	$sp^2\ ^3P_1$ - 6d $^3P_2$	0.002
462.679	216132.4	60	$sp^2\ ^1D_2$ - 7s $^3P_2$	0.001
463.290	215847.6	75	$sp^2\ ^3P_2$ - 7s $^3P_1$	-0.001
463.979	215526.9	65	$sp^2\ ^1D_2$ - 6d $^1P_1$	-0.001
465.000	215053.8	12	$sp^2\ ^3P_1$ - 6d $^3F_2$	-0.003

466.104	214544.6	80		sp^2 $^1D_2$ - 6d $^1F_3$	-0.001
469.026	213207.9	40		sp^2 $^1D_2$ - 6d $^3P_1$	-0.001
469.476	213003.5	68		sp^2 $^1D_2$ - 6d $^3D_2$	-0.002
470.190	212680.1	75		sp^2 $^3P_2$ - 6d $^3F_3$	-0.002
470.741	212431.1	45		sp^2 $^3P_2$ - 6d $^3P_2$	0.002
471.958	211883.1	60		sp^2 $^1D_2$ - 6d $^3D_3$	-0.001
473.457	211212.4	60		sp^2 $^1D_2$ - 6d $^1D_2$	-0.001
474.165	210897.2	60		sp^2 $^3P_2$ - 6d $^3F_2$	0.005
489.487	204295.7	55		sp^2 $^1D_2$ - 7s $^3P_1$	0.003
493.448	202655.7	68		sp^2 $^1S_0$ - 7s $^1P_1$	0.001
496.513	201404.5	20		sp^2 $^1D_2$ - 6d $^3D_1$	-0.003
497.194	201128.7	65		sp^2 $^1D_2$ - 6d $^3F_3$	0.001
497.809	200880.2	65	D	sp^2 $^1S_0$ - 6d $^1P_1$	0.003
				sp^2 $^1D_2$ - 6d $^3P_2$	0.003
501.635	199348.0	35		sp^2 $^1D_2$ - 6d $^3F_2$	0.002
503.615	198564.4	25		sp^2 $^1S_0$ - 6d $^3P_1$	-0.006
527.282	189651.8	30		sp^2 $^1S_0$ - 7s $^3P_1$	-0.001
535.455	186757.2	55		sp^2 $^1S_0$ - 6d $^3D_1$	0.002
554.617	180304.6	35		6d $^3F_2$ - 6s6d $^1D_2$	-0.003
561.527	178085.7	22		6d $^3F_2$ - 6s6d $^3D_1$	0.006
564.671	177094.2	15		6d $^3P_2$ - 6s6d $^3D_3$	0.005
565.456	176848.4	25		6d $^3F_3$ - 6s6d $^3D_3$	0.000
567.736	176138.1	15		sp^3 $^3P_1$ - p^{2}s(2P) $^3P_1$	0.003
573.466	174378.4	12		5d $^3F_3$ - 5d6s $^3D_2$	0.006
575.187	173856.4	21		sp^3 $^3P_2$ - p^{2}d(^{2}P) $^1F_3$	-0.010
577.247	173236.2	10		5d $^3D_1$ - 5d^2 $^1S_0$	-0.011
579.326	172614.4	5		sp^3 $^3D_3$ - p^{2}d(^{2}P) $^3D_3$	0.002
590.618	169314.3	12		5d $^3F_3$ - 5d^2 $^1G_4$	0.003
593.678	168441.6	25		6d $^1D_2$ - 6s6d $^1D_2$	-0.003
594.252	168278.7	25		6s $^1P_1$ - 6s^2 $^1S^0$	0.000
596.234	167719.5	30		sp^3 $^3D_3$ - p^{2}d(^{2}P) $^3F_4$	-0.005
599.312	166857.9	37	B	6s $^3P_1$ - 5D6s $^1D_2$	-0.004
600.358	166567.3	10		sp^3 $^3S_1$ - 5d^2 $^3P_1$	-0.003

601.848	166154.9	75	6d $^3D_3$ - 6s6d $^3D^2$	0.000
604.600	165398.6	54	sp^3 $^3D_1$ - p2s(^{2}D)$^1D^2$	0.011
605.667	165107.3	45	6d $^1F_3$ - 6s6d $^1D^2$	0.005
606.113	164985.8	25	5d $^3P_2$ - 5d6s $^3D_3$	-0.004
606.413	164904.0	10	sp^3 $^3P_0$ - p^2d(^{2}S)$^3D_1$	0.000
608.900	164230.5	12	6d $^3P_1$ - 6s6d $^3D_1$	-0.005
610.146	163895.1	33	sp^3 $^3D_2$ - p^2d(^{2}P)$^3F_3$	0.015
611.450	163545.6	5	sp^3 $^3S_1$ - p^2d(^{2}P)$^1D_2$	0.005
611.867	163434.3	26	6d $^1F_3$ - 6s6d $^3D_3$	-0.004
613.127	163098.3	53	5d $^3F_2$ - $5d^2$ $^3F_2$	0.013
617.623	161911.1	33	sp^3 $^3P_2$ - p^2d(^{2}S)$^1D_2$	-0.002
618.836	161593.7	10	5d $^3F_3$ - $5d^2$ $^3F_4$	0.006
619.398	161447.2	15	sp^3 $^3P_1$ - p^2d(^{2}S)$^1D_2$	-0.006
620.549	161147.7	35	sp^3 $^3D_2$ - p^2d(^{2}D)$^3D_3$	0.004
620.673	161115.5	64	sp^3 $^5S_2$ - p^2s(^{4}P)$^5P_3$	0.002
621.170	160986.5	10	5d $^3F_3$ - $5d^2$ $^3F_3$	0.007
626.577	159597.4	77	sp^3 $^3D_1$ - p^2d(^{2}S)$^3D_2$	-0.004
627.344	159402.1	25	5d $^1P_1$ - $6s^2$ $^1S_0$	0.000
627.842	159275.7	45	sp^2 $^3P_2$ - 5p5d $^1P_1$	0.006
630.948	158491.7	15	5d $^3D_1$ - $5d^2$ $^3P_0$	0.000
631.575	158334.2	20	sp^3 $^3D_2$ - p^2d(^{2}D)$^3S_1$	0.005
631.634	158319.5	40	sp^3 $^3D_2$ - 5p5f $^1D_2$	0.002
633.703	157802.7	15	sp^3 $^3D_1$ - 5p5f $^3D_1$	-0.001
633.761	157788.2	60	6s $^3P_1$ - 5d6s $^3D_1$	0.001
634.739	157545.0	10	sp^3 $^3S_1$ - p^2s(^{2}P)$^3P_2$	0.007
635.242	157420.2	25	sp^3 $^3P_2$ - p^2d(^{2}P)$^1P_1$	0.004
635.335	157397.3	28	sp^3 $^3D_1$ - 5p5f $^3D_2$	0.012
635.696	157308.0	28	sp^3 $^3D_2$ - 5p5f $^3D_1$	-0.001
637.119	156956.6	32	sp^3 $^3P_1$ - p^2d(^{2}P)$^1P_1$	0.000
638.586	156596.0	15	sp^3 $^3D_3$ - 5p5f $^1G_4$	0.001
640.011	156247.3	20	5d $^3D_3$ - 5d6s $^3D_2$	-0.007
640.139	156216.1	35	sp^3 $^5S_2$ - p^2s(^{4}P)$^5P_2$	0.006
641.807	155810.0	40	sp^3 $^3D_1$ - 7p $^1D_2$	-0.007
642.862	155554.3	10	sp^3 $^3D_2$ - 5p5f $^1F_3$	0.006

643.845	155316.9	60	B	$sp^3\ ^3D_2 - 7p\ ^1D_2$	-0.013
644.155	155242.2	35		$6s\ ^1P_1 - 5d^2\ ^1S_0$	-0.001
644.621	155129.8	20		$5d\ ^3F_3 - p^2d(^2P)\,^1F_3$	0.001
645.175	154996.6	35		$sp^3\ ^1P_1 - 5d^2\ ^3P_0$	0.000
647.021	154554.5	40		$sp^2\ ^3P_1 - 6s\ ^1P_1$	-0.002
648.792	154132.6	2		$sp^2\ ^3P_0 - 5d\ ^3P_1$	0.004
649.314	154008.7	50		$sp^2\ ^3P_1 - 6s\ ^3P_2$	0.000
650.445	153741.0	18		$5d\ ^3P_1 - 5d6s\ ^3D_1$	-0.001
650.563	153712.9	10		$sp^3\ ^3D_1 - p^2d(^2D)\,^3P_2$	-0.008
650.948	153622.0	45		$sp^3\ ^3D_1 - p^2d(^2D)\,^1P_1$	0.000
652.317	153299.7	65		$sp^3\ ^3D_3 - 5p5f\ ^3F_4$	-0.004
652.655	153220.2	18		$sp^3\ ^3D_3 - 7p\ ^3D_3$	-0.002
656.912	152227.4	25		$5d\ ^3D_2 - 5d^2\ ^1D_2$	0.012
657.512	152088.4	28		$sp^3\ ^3D_2 - p^2d(^2D)\,^1F_3$	0.002
658.785	151794.6	65	B	$sp^3\ ^1D_2 - p^2d(^2P)\,^3D_3$	0.010
661.343	151207.4	45		$5d\ ^3D_3 - 5d^2\ ^3P_2$	-0.002
662.514	150940.1	20		$sp^3\ ^5S_2 - p^2s(^4P)\,^5P_1$	-0.007
663.137	150798.5	10		$5d\ ^3P_2 - 5d^2\ ^3F_3$	-0.005
663.914	150621.9	20		$5d\ ^3D_1 - 5d^2\ ^3F_2$	-0.004
664.889	150401.1	55		$sp^2\ ^3P_2 - 6s\ ^1P_1$	-0.001
664.927	150392.4	25		$sp^3\ ^3D_3 - p^2d(^2D)\,^3P_2$	-0.014
665.614	150237.2	55		$sp^2\ ^3P_2 - 5d\ ^1F_3$	-0.005
666.284	150086.1	55	D	$sp^2\ ^3P_0 - 6s\ ^3P_1$	-0.001
				$5d\ ^3P_2 - 5d2\ ^3F_2$	-0.007
667.311	149855.2	60		$sp^2\ ^3P_2 - 6s\ ^3P_2$	0.001
669.971	149260.2	25		$sp^3\ ^3D_3 - p^2d(^2D)\,^1F_3$	0.008
670.211	149206.8	20		$5d\ ^3P_0 - 5d^2\ ^3P_1$	-0.007
670.730	149091.3	25		$sp^2\ ^3P_1 - 5d\ ^1D_2$	-0.001
671.148	148998.4	22		$sp^3\ ^3D_1 - p^2d(^2D)\,^3D_2$	0.004
671.393	148944.1	20		$5d\ ^3P_1 - 5d^2\ ^3P_2$	0.003
673.383	148503.9	43		$5d\ ^1D_2 - 5d^2\ ^1D_2$	0.001
675.182	148108.2	15		$5d\ ^3P_1 - 5d^2\ ^3P_1$	0.009
675.335	148074.7	70		$6s\ ^3P_2 - 5d6s\ ^3D_3$	0.004

676.926	147726.6	40		$sp^2\ {}^1D_2$ - 5d $^1P_1$	0.001
677.433	147616.1	65		$sp^3\ {}^3D_1$ - $p^2d(^2D)\,^3D_1$	0.009
678.508	147382.2	48		$sp^3\ {}^3D_2$ - $p^2d(^2D)\,^3D_3$	0.004
678.861	147305.5	65		$sp^2\ {}^3P_1$ - 5d $^3P_1$	0.000
678.980	147279.7	35		6s $^3P_2$ - 5d6s $^3D_2$	0.002
679.093	147255.3	25		$sp^3\ {}^3P_0$ - $p^2d(^2P)\,^3D_1$	0.006
679.535	147159.5	10		5d $^1D_2$ - $5d^2\ {}^3P_2$	-0.001
679.702	147123.2	40		$sp^3\ {}^3D_2$ - $p^2d(^2D)\,^3D_1$	0.001
680.102	147036.7	40		6s $^3P_0$ - $p^2s(^2P)\,^1P_1$	0.010
680.798	146886.5	65		$sp^2\ {}^3P_0$ - $sp^3\ {}^1P_1$	0.001
681.069	146828.0	20		$sp^3\ {}^3P_1$ - $p^2d(^2P)\,^3F_2$	0.000
681.742	146683.1	30		5d $^1P_1$ - 5D6s $^1D_2$	0.003
682.515	146516.9	10		$sp^3\ {}^3D_1$ - 7p $^3P_1$	-0.002
683.230	146363.7	20		5d $^1P_1$ - $5d^2\ {}^1S_0$	0.009
683.384	146330.6	20		$sp^3\ {}^1D_2$ - $p^2d(^2S)\,^3D_3$	0.005
683.947	146210.2	60		$sp^2\ {}^3P_1$ - 5d $^3P_0$	0.000
684.083	146181.1	28		$sp^3\ {}^3D_1$ - 7p $^3P_0$	0.005
685.210	145940.7	20		$sp^3\ {}^3D_2$ - 5p5f $^3F_2$	0.011
685.824	145809.9	50		5d $^3D_1$ - $p^2d(^2P)\,^3P_0$	-0.008
686.452	145676.6	40		$sp^3\ {}^3P_2$ - $p^2d(^2D)\,^3D_3$	0.003
687.052	145549.3	45		$sp^3\ {}^3D_3$ - $p^2d(^2D)\,^3G_4$	-0.013
687.352	145485.8	30		$sp^3\ {}^3D_1$ - $p^2d(^2D)\,^3P_0$	0.000
687.407	145474.3	70	B	$sp^3\ {}^3D_3$ - $p^2d(^2D)\,^3G_3$	-0.015
687.639	145425.2	30		$sp^3\ {}^5S_2$ - $p^2d(^4P)\,^5P_1$	-0.006
687.925	145364.7	65		$sp^2\ {}^3P_1$ - 5d $^3D_2$	0.000
689.948	144938.5	55	D	$sp^2\ {}^3P_2$ - 5d $^1D_2$	-0.004
				5d $^3P_2$ - $p^2d(^2P)\,^1F_3$	0.003
691.774	144555.9	50		$sp^3\ {}^5S_2$ - $p^2d(^4P)\,^5P_2$	-0.003
692.605	144382.4	50		$sp^3\ {}^3D_3$ - $p^2d(^2D)\,^3F_4$	-0.008
693.058	144288.0	15		$sp^3\ {}^3D_1$ - $p^2s(^4P)\,^3P_2$	0.006
693.486	144199.0	5		$sp^3\ {}^3P_2$ - $p^2s(^2D)\,^3D_1$	0.003
695.433	143795.3	40		$sp^3\ {}^5S_2$ - $p^2d(^4P)\,^3F_3$	0.001
696.215	143633.8	28		6s $^3P_1$ - $p^2s(^2S)\,^1S_0$	-0.005

696.928	143486.9	48		sp^3 $^3D_3$ - 7p $^3D_2$	0.000
697.050	143461.8	30		5d $^3D_3$ - 5d^2 $^3F_4$	-0.005
697.389	143391.9	75		sp^2 $^3P_0$ - 5d $^3D_1$	-0.002
698.051	143256.0	70		sp^2 $^3P_1$ - 6s $^3P_1$	0.008
698.224	143220.6	30		sp^3 $^3S_1$ - 5p^4 $^1S_0$	0.005
698.554	143152.9	55		sp^2 $^3P_2$ - 5d ^{3}P1	-0.004
698.724	143118.0	30		sp^3 $^3D_3$ - 5p5f $^3F_2$	-0.009
699.099	143041.2	18		6s $^1P_1$ - 5d^2 $^1D_2$	-0.001
699.623	142934.1	10		sp^3 $^3D_2$ - 7p $^3D_1$	0.000
699.804	142897.1	10		sp^3 $^3D_1$ - p^{2}d(^{2}D)$^3F_2$	-0.013
699.962	142864.8	20		sp^3 $^3P_2$ - p^{2}d(^{2}D)$^3S_1$	-0.004
701.228	142606.9	15		sp^3 $^3D_3$ - 5p5f $^3G_4$	0.003
701.590	142533.4	10		5d $^3D_2$ - 5d^2 $^3F_3$	-0.006
702.249	142399.6	70		sp^3 $^3D_2$ - p^{2}d(^{2}D)$^3F_2$	0.001
702.332	142382.8	75	B	sp^3 $^3P_1$ - 5p5f $^1D_2$	0.005
703.130	142221.2	55		sp^2 $^3P_1$ - 6s $^3P_0$	0.000
704.155	142014.1	45		sp^3 $^5S_2$ - p^{2}d(^{4}P)$^5P_3$	0.009
704.504	141943.8	25	B	sp^3 $^3S_1$ - p^{2}d(^{2}P)$^3D_2$	0.000
704.961	141851.9	30		sp^3 $^3D_2$ - 5p^4 $^3P_1$	0.004
705.045	141835.0	25		5d $^1F_3$ - 5d^2 $^1G_4$	-0.002
707.358	141371.1	30		sp^3 $^3P_1$ - 5p5f $^3D_1$	0.002
707.976	141247.7	25	D	sp^3 $^3S_1$ - p^{2}d(^{2}S)$^1D_2$	-0.004
				5d $^3F_3$ - p^{2}d(^{2}P)$^3D_3$	-0.004
708.161	141210.8	75		sp^2 $^3P_2$ - 5d $^3D_2$	0.004
708.590	141125.3	15		sp^3 $^3P_2$ - 7p $^3S_1$	-0.002
709.378	140968.6	40		sp^3 $^3D_3$ - p^{2}s(^{4}P)$^3P_2$	-0.005
709.780	140888.7	80		sp^2 $^3P_2$ - 5d $^3D_3$	0.007
710.948	140657.2	25		sp^3 $^3D_3$ - 5p5f $^3G_3$	0.004
711.365	140574.9	25		sp^3 $^3P_2$ - 7p $^3D_3$	0.001
712.865	140279.1	50		sp^3 $^3D_3$ - p^{2}d(^{2}D)$^3F_3$	0.004
713.987	140058.6	60		sp^2 $^3P_1$ - sp^3 $^1P_1$	0.000
714.460	139965.9	10		sp^3 $^5S_2$ - p^{2}d(^{4}P)$^3F_2$	-0.012
716.034	139658.1	25		sp^3 $^3D_2$ - p^{2}s(^{4}P)$^5P_3$	0.000
717.201	139430.9	15		5d $^3D_1$ - p^{2}d(^{2}P)$^3P_2$	-0.003

717.363	139399.4	40	B	sp^3 $^3D_2$ - $p^2s(^4P)^3P_1$	-0.007
717.489	139375.0	15		sp^3 $^3P_1$ - 7p $^1D_2$	0.012
718.808	139119.3	30		sp^3 $^1D^2$ - $p^2d(^2P)^3F_2$	0.000
718.883	139104.7	70		sp^2 $^3P_2$ - 6s $^3P_1$	-0.002
719.622	138961.8	10		5d $^3F_2$ - $p^2d(^2D)^1D_2$	-0.010
719.977	138893.3	40		5d $^3P_2$ - $p^2d(^2P)^3P^2$	0.003
720.199	138850.5	72		sp^2 $^1D_2$ - 6s $^1P_1$	-0.001
720.435	138805.1	55		5d $^1D_2$ - $5d^2$ $^3F_3$	0.005
721.061	138684.5	85		sp^2 $^1D_2$ - 5d $^1F_3$	0.006
721.454	138609.0	20		sp^3 $^3D_2$ - $p^2d(^4P)^3D_3$	0.008
723.039	138305.1	55		sp^2 $^1D_2$ - 6s $^3P_2$	-0.001
724.491	138027.9	75		sp^3 $^3D_1$ - $p^2d(^4P)^3D_1$	-0.013
724.586	138009.8	5		sp^3 $^3P_0$ - $p^2d(^2D)^1P_1$	0.005
725.241	137885.2	20		sp^3 $^3D_2$ - $5p^4$ $^3P_2$	-0.003
725.465	137842.7	20		6s $^1P_1$ - $p^2d(^2P)^1D_2$	-0.004
725.967	137747.3	25		sp^3 $^3P_2$ - $p^2d(^2D)^3P_2$	-0.014
726.445	137656.6	15		sp^3 $^3P_2$ - $p^2d(^2D)^1P_1$	-0.005
727.212	137511.4	15		sp^3 $^3D_1$ - $p^2d(^2D)^1S_0$	0.014
727.245	137505.3	20		sp^3 $^1D_2$ - $p^2d(^2D)^3D_3$	-0.008
728.424	137282.6	35		sp^3 $^3P_1$ - $p^2d(^2D)^3P_2$	-0.014
729.404	137098.2	80		sp^2 $^3P_1$ - 5d $^3P_2$	0.007
729.652	137051.7	20		sp^3 $^3D_3$ - $p^2d(^2D)^1G_4$	-0.007
730.826	136831.5	20		sp^3 $^3D_3$ - $p^2s(^4P)^5P_3$	-0.002
731.218	136758.2	25		sp^3 $^3S_1$ - $p^2d(^2P)^1P_1$	-0.003
731.965	136618.5	30		sp^3 $^3P_0$ - $p^2d(^2D)^3P_1$	-0.009
732.255	136564.4	40		sp^2 $^3P_1$ - 5d $^3D_1$	-0.006
733.772	136282.1	10		sp^3 $^3D_1$ - $p^{2d}(^4P)^3D_2$	-0.006
733.885	136261.1	25		sp^3 $^3P_2$ - $p^{2d}(^2D)^3P_1$	0.003
735.025	136049.8	20		sp^3 $^3D_1$ - $p^{2s}(^4P)^3P_0$	0.000
735.150	136026.7	20		sp^3 $^1D_2$ - $p^{2s}(^2D)^3D_1$	-0.003
735.652	135933.9	5		sp^3 $^1P_1$ - $p^{2d}(^2P)^3P_2$	0.006
735.801	135906.3	50		sp^2 $^3P_2$ - sp^3 $^1P_1$	-0.005
736.458	135785.1	20	D	sp^3 $^3D_2$ - $p^2d(^4P)^3D_2$	0.006

				$sp^3\ ^3D_3$ - $p^2d(^4P)^3D_3$	-0.008
737.044	135677.1	60		$sp^2\ ^3P_0$ - $sp^3\ ^3S_1$	0.001
738.229	135459.3	25		$sp^3\ 5S^2$ - $5p^4\ ^1D_2$	0.018
740.385	135064.9	30	D	$sp^3\ ^3P_1$ - $5p^4\ ^3P_0$	-0.001
				$5d\ ^3P_1$ - $p^2d(^2P)^3P_0$	0.007
740.481	135047.3	25		$sp^3\ ^5S_2$ - $p^2d(^4P)^5D_3$	0.000
741.809	134805.5	45		$sp^3\ ^5S_2$ - $p^2d(^4P)^5D_1$	0.000
742.058	134760.3	25		$sp^3\ ^3D_2$ - $p^2s(^4P)^5P_2$	-0.004
742.350	134707.4	10		$6s\ ^1P_1$ - $p^2s(^2P)^1P_1$	-0.008
742.523	134676.0	20		$sp^3\ ^1D_2$ - $5p5f\ ^1D_2$	-0.005
744.984	134231.0	25		$5d\ ^3D_1$ - $p^2d(^2P)^3D_2$	-0.009
745.344	134166.2	18		$5d\ ^1P_1$ - $5d^2\ ^1D_2$	-0.009
748.859	133536.4	20		$sp^3\ ^1D_2$ - $7p\ ^3P_2$	-0.016
749.702	133386.3	85		$sp^2\ ^1D_2$ - $5d\ ^1D_2$	0.006
750.191	133299.3	20		$5d\ ^3D_2$ - $p^2d(^2P)^3P_1$	0.002
751.410	133083.1	70		$sp^2\ ^1S_0$ - $5d\ ^1P_1$	-0.009
751.901	132996.2	15		$5d\ ^3P_2$ - $p^2d(^2S)^1D_2$	0.000
752.156	132951.2	30		$sp^3\ ^1D_2$ - $7p\ ^3S_1$	0.002
752.180	132946.9	75		$sp^2\ ^3P_2$ - $5d\ ^3P_2$	-0.003
752.423	132903.9	30	B	$sp^3\ ^1P_1$ - $p^2s(^2S)^3S_1$	-0.009
754.318	132570.0	25		$sp^3\ ^3P_1$ - $p^2d(^2D)^3D_2$	-0.010
754.531	132532.6	5		$5d\ ^3F_2$ - $p^2d(^2P)^3F_3$	-0.013
754.782	132488.6	20		$5d\ ^3F_2$ - $p^2s(^2D)^3D_2$	-0.001
754.990	132452.1	15		$5d\ ^3P_0$ - $p^2d(^2P)^3P_1$	0.013
755.232	132409.7	65		$sp^2\ ^3P_2$ - $5d\ ^3D_1$	0.002
755.353	132388.4	20		$6s\ ^3P_2$ - $p^2s(^2P)^3P_2$	-0.007
755.655	132335.6	30		$6s\ ^1P_1$ - $p^2s(^2S)^1S_0$	0.004
757.522	132009.3	15		$sp^3\ ^1P_1$ - $5p^4\ ^1S_0$	0.015
758.082	131911.8	25		$6s\ ^3P_1$ - $p^2s(^2P)^3P_0$	0.000
758.487	131841.4	40		$6s\ ^1P_1$ - $p^2s(^2P)^3P_2$	0.002
759.864	131602.5	68		$sp^2\ ^1D_2$ - $5d\ ^3P_1$	-0.005
761.051	131397.3	30		$5d\ ^3F_2$ - $p^2d(^2P)^3F_2$	-0.010
762.262	131188.5	15		$sp^3\ ^3P_1$ - $p^2d(^2D)^3D_1$	-0.008

768.726	130085.3	10		$sp^3\ ^3P_1 - 7p\ ^3P_1$	0.001
769.373	129975.9	15		$sp^3\ ^3D_1 - p^2s(^4P)^5P_1$	-0.003
770.529	129781.0	1		$5d\ ^3F_2 - p^2d(^2D)^3D_3$	-0.006
770.989	129703.5	20		$5d\ ^3F_3 - p^2d(^2P)^3F_3$	0.003
771.236	129662.0	60	D	$sp^2\ ^1D_2 - 5d\ ^3D_2$	-0.005
				$5d\ ^3F_3 - p^2s(^2D)^3D_2$	0.001
771.748	129575.9	25		$5d\ ^1D_2 - p^2d(^2P)^3P_1$	-0.014
772.324	129479.3	20		$sp^3\ ^3D_2 - p^2s(^4P)^5P_1$	0.008
773.150	129341.0	65		$sp^2\ ^1D_2 - 5d\ ^3D_3$	-0.008
776.100	128849.4	65		$sp^2\ ^3P_1 - sp^3\ ^3S_1$	-0.002
776.300	128816.1	35		$6s\ ^3P_1 - 5p^4\ ^1S_0$	-0.019
777.668	128589.6	50		$sp^3\ 5S^2 - p^2d(^4P)^5F_3$	0.000
777.799	128568.0	10		$5d\ ^3F_3 - p^2d(^2P)^3F_2$	0.008
778.539	128445.7	30		$sp^3\ ^1D_2 - p^2d(^2D)^1F_3$	-0.010
781.165	128013.9	30		$sp^3\ ^3P_2 - 5p5f\ ^3G_3$	-0.003
782.081	127864.0	15		$5d\ ^3P_1 - p^2s(^2P)^3P_0$	0.000
782.873	127734.6	30		$5d\ ^3F_2 - p^2d(^2S)^3D_2$	-0.010
782.962	127720.2	40		$sp^3\ ^3S_1 - p^2s(^2D)^3D_2$	0.010
783.398	127649.0	15		$5d\ ^1F_3 - p^2d(^2P)^1F_3$	0.003
783.479	127635.9	10		$sp^3\ ^3P_2 - p^2d(^2D)^3F_3$	-0.003
783.978	127554.6	55		$sp^2\ ^1D_2 - 6s\ ^3P_1$	-0.004
787.703	126951.4	45		$5d\ ^3F_2 - 5p5f\ ^1D_2$	-0.001
788.001	126903.4	35	B	$5d\ ^1D_2 - p^2d(^2P)^3P_2$	-0.005
790.361	126524.5	20		$5d\ ^3P_0 - p^2d(^2S)^3D_1$	-0.003
790.752	126461.9	10		$sp^3\ ^3P_1 - p^2d(^2D)^3F_2$	0.010
790.939	126432.0	45		$sp^3\ ^5S_2 - p^2d(^4P)^5F_2$	0.011
791.253	126381.8	30		$sp^3\ ^3P_2 - 5p^4\ ^3P_1$	-0.003
792.154	126238.1	90	B	$sp^3\ ^3S_1 - p^2d(^2P)^3D_1$	-0.001
794.020	125941.4	20		$5d\ 3P_2 - p^2d(^2D)^1D_2$	0.008
794.837	125812.0	5		$5d\ 3F_2 - 7p\ ^3P_2$	0.015

795.821	125656.4	35		5d 3P_1 - $p^2s(^2S)^3S_1$	-0.006
796.246	125589.4	10		5d 3P_2 - $p^2d(^2S)^3D_3$	0.009
797.268	125428.4	35		5d $^3P_1$ - $p^2d(^2S)^3D_1$	0.003
799.672	125051.3	30		5d $^3D_3$ - $p^2d(^2S)^1D_2$	0.007
800.614	124904.2	5		5d $^3F_3$ - $p^2d(^2S)^3D_2$	0.016
801.951	124695.9	75		sp^2 $^3P_2$ - sp^3 $^3S_1$	-0.001
804.146	124355.5	65		sp^2 $^1D_2$ - sp^3 $^1P_1$	-0.004
804.616	124282.9	10		sp^3 $^3P_0$ - $p^2s(^4P)^3P_1$	-0.008
805.113	124206.2	50		sp^2 $^1S_0$ - 6s $^1P_1$	-0.007
805.913	124082.9	80		sp^2 $^3P_1$ - 5d $^3F_2$	-0.003
806.814	123944.3	35		5d $^3F_2$ - 7p $^1D_2$	0.004
808.166	123736.9	45		5d $^3F_2$ - 7p $^1P_1$	-0.005
809.786	123489.4	10		5d $^3P_1$ - $p^2d(^2P)^3D_2$	-0.013
812.261	123113.1	60		5d $^3D_3$ - $p^2d(^2P)^3D_3$	-0.005
813.328	122951.6	15		sp^3 $^3D_3$ - $p^2d(^4P)^3F_4$	0.012
814.386	122791.9	25		5d $^3D_2$ - $p^2d(^2P)^3D_3$	-0.007
814.627	122755.6	85		sp^2 $^3P_2$ - 5d $^3F_3$	-0.001
816.907	122412.9	30	D	sp^3 $^3P_0$ - $p^2d(^4P)^3D_1$	0.010
				sp^3 $^3P_2$ - $5p^4$ $^3P_2$	0.002
821.168	121777.8	25		sp^3 $^1D_2$ - 5p5f $^3D_3$	-0.006
821.701	121698.8	15		5d $^1D_2$ - $p^2d(^2P)^3D_2$	0.020
823.745	121396.8	65		sp^2 $^1D_2$ - 5d $^3P_2$	-0.006
825.869	121084.6	35		sp^3 $^3P_1$ - $p^2d(^2D)^1S_0$	-0.011
827.401	120860.4	60		sp^2 $^1D_2$ - 5d $^3D_1$	-0.005
828.363	120720.0	25		5d $^3F_2$ - $p^2d(^2D)^1F_3$	0.002
829.469	120559.1	28		sp^3 $^3D_2$ - $p^2d(^4P)^5P_3$	-0.007
831.447	120272.3	8		sp^3 $^3D_3$ - $p^2d(^4P)^5P_2$	-0.013
833.818	119930.2	70		sp^2 $^3P_2$ - 5d $^3F_2$	-0.007
834.446	119840.0	60		sp^3 $^1D_2$ - 5p5f $^3G_3$	0.000
836.744	119510.9	10		sp^3 $^3D_3$ - $p^2d(^4P)^3F_3$	-0.001
839.887	119063.7	60		5d $^1D_2$ - $p^2d(^2P)^3D_3$	0.007
840.343	118999.0	35		sp^3 $^3D_1$ - $p^2d(^4P)^3F_2$	0.009
844.750	118378.2	25	B	5d $^3P_2$ - $p^2d(^2P)^3F_2$	0.002

845.917	118214.9	45	5d $^3D_3$ - $p^2d(^2P)^3F_4$	0.003
852.317	117327.2	10	5d $^3D_2$ - $p^2d(^2S)^3D_3$	-0.011
855.226	116928.1	15	5d $^3F_2$ - $p^2d(^2D)^3G_3$	0.009
856.443	116762.0	35	5d $^3P_2$ - $p^2d(^2D)^3D_3$	0.007
859.413	116358.5	65	sp^2 $^3P_1$ - sp^3 $^1D_2$	0.001
861.959	116014.8	35	5d $^3F_2$ - $p^2d(^2D)^3D_3$	-0.003
865.959	115478.9	80	sp^2 $^3P_0$ - sp^3 $^3P_1$	-0.004
867.659	115252.6	30	5d $^3D_1$ - $p^2d(^2S)^3D_2$	-0.003
869.969	114946.6	10	5d $^3F_2$ - 7p $^3D_2$	-0.012
870.583	114865.6	10	sp^3 $^3S_1$ - $5p^4$ $^3P_0$	0.001
872.790	114575.1	15	5d $^3F_2$ - 5p5f $^3F_2$	-0.006
876.176	114132.3	20	sp^3 $^3D_1$ - $p^2d(^4P)^5D_0$	0.000
876.789	114052.5	10	5d $^3F_2$ - 5p5f $^3D_3$	0.005
883.818	113145.5	10	sp^2 $^1D_2$ - sp^3 $^3S_1$	-0.002
885.670	112908.9	30	sp^2 $^1S_0$ - 6s $^3P_1$	-0.002
889.453	112428.6	40	sp^3 $^3D_2$ - $p^2d(^4P)^5D_2$	-0.003
891.225	112205.1	65	sp^2 $^3P_2$ - sp^3 $^1D_2$	0.002
891.923	112117.3	28	5d $^3F_3$ - 7p $^3D_2$	0.011
894.799	111757.0	20	sp^3 $^1P_1$ - $p^2d(^2S)^3D_2$	-0.001
898.961	111239.5	40	5d $^3F_3$ - 5p5f $^3G_4$	-0.002
899.241	111204.9	80	sp^2 $^1D_2$ - 5d $^3F_3$	0.002
911.502	109709.0	20	sp^2 $^1S_0$ - sp^3 $^1P_1$	0.005
911.651	109691.1	15	6s $^3P_1$ - 7p $^1S_0$	0.000
912.406	109600.3	28	sp^3 $^3D_1$ - $p^2d(^4P)^3P_0$	0.000
918.847	108832.0	25	sp^3 $^3D_1$ - $p^2d(^4P)^3P_1$	-0.001
920.380	108650.8	80	sp^2 $^3P_1$ - sp^3 $^3P_1$	-0.006
921.710	108494.0	15	sp^3 $^3P_2$ - $p^2d(^4P)^5P_1$	0.004
922.702	108377.4	70	sp^2 $^1D_2$ - 5d $^3F_2$	0.012
923.045	108337.1	35	sp^3 $^3D_2$ - $p^2d(^4P)^3P_1$	0.001
924.325	108187.1	85	sp^2 $^3P_1$ - sp^3 3P2	-0.015
927.384	107830.2	70	sp^2 $^3P_1$ - sp^3 $^3P_0$	0.000
929.156	107624.5	35	sp^3 $^3P_2$ - $p^2d(^4P)^5P_2$	0.012
930.400	107480.7	15	5d $^1D_2$ - $p^2s(^2D)^3D_2$	-0.007

931.559	107346.9	15		5d $^3P_2$ - $p^2d(^2D)\,^3P_1$	0.004
941.498	106213.7	35		$sp^2\ ^1S_0$ - 5d $^3D_1$	0.005
946.218	105683.9	10		5d $^3F_3$ - $p^2d(^2D)\,^1G_4$	-0.015
956.707	104525.2	5		5d $^3D_2$ - 7p $^3P_2$	0.020
956.974	104496.0	50		$sp^2\ ^3P_2$ - $sp^3\ ^3P_1$	0.007
959.189	104254.7	15		5d $^3D_2$ - 5p5f $^3D_2$	-0.001
960.212	104143.7	20		5d $^3D_3$ - 5p5f $^3F_3$	-0.002
960.447	104118.2	15		5d $^3P_2$ - $p^2d(^2D)\,^3D_2$	0.005
960.798	104080.2	20		$sp^3\ ^3D_1$ - $p^2d(^4P)\,^5F_1$	0.000
961.234	104032.9	85		$sp^2\ ^3P_2$ - $sp^3\ ^3P_2$	-0.008
963.180	103822.8	10		5d $^3D_2$ - 5p5f $^3F_3$	-0.006
963.429	103795.9	1		5d $^3D_3$ - 5p5f $^3F_4$	0.002
971.023	102984.2	20		5d $^3D_3$ - 7p $^1D_2$	-0.001
971.771	102904.9	20		5d $^3D_2$ - 5p5f $^1F_3$	-0.002
977.380	102314.4	6		5d $^3P_1$ - 5p5f $^3D_2$	-0.004
978.955	102149.7	5		$sp^3\ ^3D_3$ - $p^2d(^4P)\,^5F_2$	-0.007
981.951	101838.1	20		5d $^3D_1$ - 7p $^3P_0$	-0.002
991.238	100883.9	10		5d $^3D_3$ - $p^2d(^2D)\,^3P_2$	0.027
993.487	100655.6	75		$sp^2\ ^1D_2$ - $sp^3\ ^1D_2$	- 0.006
994.378	100565.4	10		5d $^3D_2$ - $p^2d(^2D)\,^3P_2$	-0.002
999.049	100095.2	50	B	5d $^1D_2$ - 5p5f $^3F_3$	0.007
1002.928	99708.1	25		$sp^3\ ^3D_3$ - $p^2d(^4P)\,^3P_2$	0.027
1009.623	99046.9	80		$sp^2\ ^3P_0$ - $sp^3\ ^3D_1$	0.004
1014.220	98597.9	12		$sp^3\ ^1P_1$ - 5p5f $^3F_2$	0.004
1015.236	98499.3	20		$sp^2\ ^1S_0$ - $sp^3\ ^3S_1$	0.007
1019.688	98069.2	15		$sp^3\ ^3P_1$ - $5p^4\ ^1D_2$	-0.009
1023.043	97747.6	25		5d $^1F_3$ - 5p5f $^1G_4$	0.000
1036.334	96494.0	30	B	$sp^3\ ^3P_1$ - $p^2d(^4P)\,^5D_2$	- 0.023
1041.198	96043.2	5		5d $^3D_3$ - $p^2d(^2D)\,^3G_4$	0.006
1072.222	93264.3	1		6s $^1P_1$ - 7p $^1P_1$	0.003
1075.895	92945.9	5		$sp^2\ ^1D_2$ - $sp^3\ ^3P_1$	0.006
1078.595	92713.2	85		$sp^2\ ^3P_1$ - $sp^3\ ^3D_2$	0.007
1081.308	92480.6	55		$sp^2\ ^1D_2$ - $sp^3\ ^3P_2$	0.012
1084.375	92219.0	40		$sp^2\ ^3P_1$ - $sp^3\ ^3D_1$	0.001

1091.872	91585.8	25	5d $^3F_3$ - $p^2d(^4P)\,^3F_4$	-0.006
1094.242	91387.5	80	sp^2 $^3P_2$ - sp^3 $^3D_3$	-0.001
1112.471	89890.0	30	6s $^3P_0$ - $p^2s(^4P)\,^3P_1$	0.007
1129.163	88561.2	2	sp^2 $^3P_2$ - sp^3 $^3D_2$	-0.009
1135.504	88066.6	45	sp^2 $^3P_2$ - sp^3 $^3D_1$	-0.010
1142.249	87546.6	12	5d $^3D_3$ - $p^2d(^2D)\,^1G_4$	0.013
1169.153	85532.0	40	5d $^1F_3$ - $p^2d(^2D)\,^3F_4$	0.003
1252.554	79836.9	80	sp^2 $^1D_2$ - sp^3 $^3D_3$	0.002
1267.525	78893.9	20	sp^3 $^1D_2$ - $p^2d(^4P)\,^3P_2$	-0.017
1306.928	76515.3	60	sp^2 $^1D_2$ - sp^3 $^3D_1$	0.002
1317.580	75896.7	23	5d $^3F_3$ - $p^2d(^4P)\,^5F_4$	0.001
1490.260	67102.4	80	sp^2 $^3P_2$ - sp^3 $5S_2$	0.004
1731.236	57762.2	20	5d $^3D_3$ - $p^2d(^4P)\,^5F_4$	-0.001
1784.099	56050.7	40	5d $^1D_2$ - $p^2d(^4P)\,^5D_2$	0.009
1800.096	55552.6	10	sp^2 $^1D_2$ - sp^3 $^5S_2$	-0.013
1852.909	53969.2	25	5d $^1F_3$ - $p^2d(^4P)\,^5D_4$	0.000

a: Character of lines viz. B stands for blended line, D for doubly classified lines

b: sp^2 stands for $5s5p^2$; sp^3 stands for $5s5p^3$; 5d, 6d,7d, 6s, 7s, and 8s stand for 5p5d, 5p6d, 5p7d, 5p6s, 5p7s, and 5p8s; p^2d and p^2s stand for $5s5p^25d$ and $5s5p^26s$.

c: diff. $(\Delta\lambda)$ = observed λ –calculated λ from levels in Table 4.2 & 4.3

Table 4.2. Observed and least squares fitted energy levels (in cm^{-1}) for odd parity configurations of I IV

J	E(obs)	E(LSF)	diff.	LS-composition.	
0	114658.4	114738.0	-79.6	89% 5s $5p^3(^2P)\,^3P$	+ 11% $5s^2$ 5p 5d ^3P
	149049.4	149134.0	-84.6	97% $5s^2$ 5p 6s ^3P	
	153038.4	152974.0	64.4	87% $5s^2$ 5p 5d ^3P	+ 10% 5s $5p^3(^2P)\,^3P$
	226534.6	226539.0	-4.4	100% $5s^2$ 5p 7s ^3P	
	236360.1	236196.0	164.1	100% $5s^2$ 5p 6d ^3P	
	262075.1	262072.0	3.1	100% $5s^2$ 5p 8s ^3P	
	272563.1	272624.0	-60.9	100% $5s^2$ 5p 7d ^3P	
1	99047.3	99126.0	-78.7	76% 5s $5p^3(^2D)\,^3D$	+ 11% $5s^2$ 5p 5d ^3D
				+ 9% 5s $5p^3(^2P)\,^3P$	
	115478.3	115447.0	31.3	78% 5s $5p^3(^2P)\,^3P$	+ 10% $5s^2$ 5p 5d ^3P
				+ 8% 5s $5p^3(^2D)\,^3D$	
	135677.2	135617.0	60.2	60% 5s $5p^3(^4S)\,^3S$	+ 30% 5s $5p^3(^2P)\,^1P$
				+ 6% $5s^2$ 5p 5d ^1P	
	143391.5	143379.0	12.5	30% $5s^2$ 5p 5d ^3D	+ 21% $5s^2$ 5p 5d ^1P
				+ 21% $5s^2$ 5p 5d ^3P	+ 9% 5s $5p^3(^4S)\,^3S$
	146886.8	146979.0	-92.2	36% $5s^2$ 5p 5d ^3D	+ 26% 5s $5p^3(^2P)\,^1P$
				+ 23% 5s $5p^3(^4S)\,^3S$	+ 6% $5s^2$ 5p 5d ^1P
	150085.8	149994.0	91.8	70% $5s^2$ 5p 6s ^3P	+ 20% $5s^2$ 5p 6s ^1P
	154133.6	154071.0	62.6	63% $5s^2$ 5p 5d ^3P	+ 14% $5s^2$ 5p 5d ^3D
				+ 9% 5s $5p^3(^2P)\,^3P$	
	161382.3	161728.0	-345.7	62% $5s^2$ 5p 6s ^1P	+ 23% $5s^2$ 5p 6s ^3P
				+ 8% 5s $5p^3(^2P)\,^1P$	+ 5% $5s^2$ 5p 5d ^1P
	170258.7	170075.0	183.7	59% $5s^2$ 5p 5d ^1P	+ 20% 5s $5p^3(^2P)\,^1P$
				+ 13% $5s^2$ 5p 6s ^1P	
	223935.1	224091.0	-155.9	64% $5s^2$ 5p 6d ^3D	+ 20% $5s^2$ 5p 6d ^1P
				+ 15% $5s^2$ 5p 6d ^3P	
	226828.7	226826.0	2.7	70% $5s^2$ 5p 7s ^3P	+ 30% $5s^2$ 5p 7s ^1P
	235739.3	235722.0	17.3	68% $5s^2$ 5p 6d ^3P	+ 27% $5s^2$ 5p 6d ^3D
	238058.5	238202.0	-143.5	57% $5s^2$ 5p 6d ^1P	+ 15% $5s^2$ 5p 6d ^3P
				+ 12% $5s^2$ 5p 7s ^1P	+ 8% $5s^2$ 5p 7s ^3P
	239833.4	239685.0	148.4	57% $5s^2$ 5p 7s ^1P	+ 22% $5s^2$ 5p 7s ^3P
				+ 17% $5s^2$ 5p 6d ^1P	
	260877.7	260760.0	117.7	56% $5s^2$ 5p 7d ^3D	+ 26% $5s^2$ 5p 7d ^1P
				+ 17% $5s^2$ 5p 7d ^3P	
	262220.3	262223.0	-2.7	68% $5s^2$ 5p 8s ^3P	+ 31% $5s^2$ 5p 8s ^1P

	272440.4	272449.0	-8.6	66% $5s^2$ 5p 7d ^3P + 31% $5s^2$ 5p 7d ^3D
	273775.6	273667.0	108.6	64% $5s^2$ 5p 7d ^1P + 17% $5s^2$ 5p 7d ^3P
				+ 11% $5s^2$ 5p 7d ^3D + 5% $5s^2$ 5p 8s ^1P
	274561.0	274587.0	-26.0	63% $5s^2$ 5p 8s ^1P + 28% $5s^2$ 5p 8s ^3P
				+ 7% $5s^2$ 5p 7d ^1P
2	78084.1	78106.0	-21.9	95% 5s $5p^3(^4S)\,^5S$ + 4% 5s $5p^3(^2P)\,^3P$
	99542.0	99501.0	41.0	74% 5s $5p^3(^2D)\,^3D$ + 12% 5s $5p^3(^2P)\,^3P$
				+ 10% $5s^2$ 5p 5d ^3D
	115013.5	114953.0	60.5	42% 5s $5p^3(^2P)\,^3P$ + 18% 5s $5p^3(^2D)\,^1D$
				+ 15% $5s^2$ 5p 5d ^1D + 10% 5s $5p^3(^2D)\,^3D$
	123186.9	123126.0	60.9	36% $5s^2$ 5p 5d ^1D + 28% 5s $5p^3(^2P)\,^3P$
				+ 21% 5s $5p^3(^2D)\,^1D$ + 8% $5s^2$ 5p 5d ^3F
	130910.7	130934.0	-23.3	88% $5s^2$ 5p 5d ^3F + 7% 5s $5p^3(^2D)\,^1D$
	143927.8	143922.0	5.8	49% $5s^2$ 5p 5d ^3P + 29% $5s^2$ 5p 5d ^3D
				+ 9% 5s $5p^3(^2D)\,^1D$ + 5% 5s $5p^3(^2P)\,^3P$
	152193.0	152321.0	-128.0	49% $5s^2$ 5p 5d ^3D + 16% $5s^2$ 5p 5d ^1D
				+ 16% 5s $5p^3(^2D)\,^1D$ + 9% $5s^2$ 5p 5d ^3P
	155919.2	156100.0	-180.8	28% $5s^2$ 5p 5d ^3P + 27% 5s $5p^3(^2D)\,^1D$
				+ 26% $5s^2$ 5p 5d ^1D + 8% $5s^2$ 5p 5d ^3D
	160836.9	160565.0	271.9	99% $5s^2$ 5p 6s ^3P
	221880.8	221734.0	146.8	73% $5s^2$ 5p 6d ^3F + 22% $5s^2$ 5p 6d ^1D
	223413.4	223421.0	-7.6	39% $5s^2$ 5p 6d ^3P + 38% $5s^2$ 5p 6d ^3D
				+ 19% $5s^2$ 5p 6d ^1D + 4% $5s^2$ 5p 6d ^3F
	233744.0	233618.0	126.0	50% $5s^2$ 5p 6d ^1D + 26% $5s^2$ 5p 6d ^3D
				+ 22% $5s^2$ 5p 6d ^3F
	235534.5	235459.0	75.5	57% $5s^2$ 5p 6d ^3P + 33% $5s^2$ 5p 6d ^3D
				+ 9% $5s^2$ 5p 6d ^1D
	238664.9	238755.0	-90.1	99% $5s^2$ 5p 7s ^3P
	259669.1	259673.0	-3.9	75% $5s^2$ 5p 7d ^3F + 20% $5s^2$ 5p 7d ^1D
	260243.0	260403.0	-160.0	45% $5s^2$ 5p 7d ^3P + 36% $5s^2$ 5p 7d ^3D
				+ 16% $5s^2$ 5p 7d ^1D
	271648.4	271691.0	-42.6	53% $5s^2$ 5p 7d ^1D + 24% $5s^2$ 5p 7d ^3D
				+ 22% $5s^2$ 5p 7d ^3F
	272510.7	272382.0	128.7	52% $5s^2$ 5p 7d ^3P + 36% $5s^2$ 5p 7d ^3D
				+ 11% $5s^2$ 5p 7d ^1D
	274226.0	274212.0	14.0	99% $5s^2$ 5p 8s ^3P
3	102368.9	102311.0	57.9	88% 5s 5p3(2D)3D + 12% $5s^2$ 5p 5d ^3D
	133737.0	133799.0	-62.0	94% $5s^2$ 5p 5d 3F
	151871.6	151602.0	269.6	79% $5s^2$ 5p 5d 3D + 10% 5s $5p^3(^2D)\,^3D$
				+ 6% $5s^2$ 5p 5d 1F + 5% $5s^2$ 5p 5d ^3F

	161217.5	161394.0	-176.5	91% 5s^2 5p 5d 1F	+ 7% 5s^2 5p 5d ^{3}D
	223660.9	223639.0	21.9	56% 5s^2 5p 6d 3F	+ 24% 5s^2 5p 6d ^{3}D
				+ 19% 5s^2 5p 6d 1F	
	234414.6	234371.0	43.6	63% 5s^2 5p 6d 3D	+ 35% 5s^2 5p 6d ^{3}F
	237075.9	237425.0	-349.1	78% 5s^2 5p 6d 1F	+ 12% 5s^2 5p 6d ^{3}D
				+ 9% 5s^2 5p 6d 3F	
	260674.8	260627.0	47.8	50% 5s^2 5p 7d 3F	+ 26% 5s^2 5p 7d ^{1}F
				+ 24% 5s^2 5p 7d 3D	
	272043.7	271990.0	53.7	60% 5s^2 5p 7d 3D	+ 39% 5s^2 5p 7d ^{3}F
	273108.9	273274.0	-165.1	72% 5s^2 5p 7d 1F	+ 17% 5s^2 5p 7d ^{3}D
				+ 11% 5s^2 5p 7d 3F	
4	-	140535.0	-	100% 5s^2 5p 5d 3F	
	-	234084.0	-	100% 5s^2 5p 6d 3F	
	-	271892.0	-	100% 5s^2 5p 7d 3F	

J	E(obs)	E(LSF)	diff.	LS-composition.
0	0.0	-54.0	54.0	89% 5s^2 5p^2 ^{3}P
				+ 9% 5s^2 5p^2 ^{1}S
	37177.2	37207.0	-29.8	88% 5s^2 5p^2 ^{1}S
				+ 9% 5s^2 5p^2 ^{3}P
	-	185918.0	-	87% 5s^2 5p 6p ^{3}P
				+ 11% 5s^2 5p 6p ^{1}S
	-	206431.0	-	86% 5s^2 5p 6p ^{1}S
				+ 11% 5s^2 5p 6p ^{3}P
	208647.6	208791.0	-143.4	47% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}P
				+ 23% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
				+ 23% 5p^4 ^{3}P
	213179.6	212929.0	250.6	76% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
				+ 11% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}P
				+ 10% 5p^4 ^{3}P
	235097.1	234956.0	141.1	86% 5s 5p^2 6s ((^{3}P)^{4}P)^{3}P
				+ 4% 5s^2 5p 7p ^{3}P
	236561.3	236763.0	-201.7	44% 5s 5p^2 5d ((^{1}D)^{2}D)^{1}S
				+ 32% 5p^4 ^{1}S
				+ 10% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}P
	244533.1	244397.0	136.1	54% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}P
				+ 14% 5s^2 5d^2 ^{3}P
				+ 13% 5p^4 ^{3}P
				+ 5% 5s 5p2 5d ((^{1}D)^{2}D)^{1}S
	245229.4	245171.0	58.4	70% 5s^2 5p 7p ^{3}P
				+ 17% 5s^2 5p 7p ^{1}S
				+ 4% 5s 5p^2 6s ((^{3}P)^{4}P)^{3}P
	250542.9	250594.0	-51.1	27% 5p^4 ^{3}P
				+ 24% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}P
				+ 19% 5s 5p^2 5d ((^{3}P)^{2}P)^{3}P
				+ 15% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}P
	259776.9	259785.0	-8.1	78% 5s^2 5p 7p ^{1}S
				+ 19% 5s^2 5p 7p ^{3}P
	278898.8	278628.0	270.8	24% 5p^4 ^{1}S
				+ 23% 5s 5p^2 5d ((^{3}P)^{2}P)^{3}P
				+ 19% 5s 5p^2 6s ((^{3}P)^{2}P)^{3}P
				+ 11% 5s 5p^2 6s ((^{1}S)^{2}S)^{1}S
	281997.6	281949.0	48.6	46% 5s 5p^2 6s ((^{3}P)^{2}P)^{3}P
				+ 19% 5s 5p^2 6s ((^{1}S)^{2}S)^{1}S
				+ 10% 5s 5p^2 5d ((^{3}P)^{2}P)^{3}P
				+ 9% 5p^4 ^{1}S
	289199.7	289228.0	-28.3	36% 5s 5p^2 5d ((^{3}P)^{2}P)^{3}P
				+ 18% 5p^4 ^{3}P
				+ 16% 5p^4 ^{1}S
				+ 13% 5s^2 5d^2 ^{1}S
	293718.6	293745.0	-26.4	59% 5s 5p^2 6s ((^{1}S)^{2}S)^{1}S
				+ 30% 5s 5p^2 6s ((^{3}P)^{2}P)^{3}P
	301883.3	301690.0	193.3	77% 5s^2 5d^2 ^{3}P
				+ 20% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}P

	316624.3	316740.0	-115.7	43% $5s^2\ 6s^2$
				+ 31% $5s^2\ 5d^2$ ^1S
				+ 16% $5s\ 5p^2\ 5d$ $((^1D)^2D)^1S$
				+ 8% $5p^4$ ^1S
	329660.9	329574.0	86.9	56% $5s^2\ 6s^2$
				+ 31% $5s^2\ 5d^2$ ^1S
				+ 8% $5s\ 5p^2\ 5d$ $((^1D)^2D)^1S$
1	6828.2	6940.0	-111.8	98% $5s^2\ 5p^2$ ^3P
	-	181553.0	-	62% $5s^2\ 5p\ 6p$ ^3D
				+ 34% $5s^2\ 5p\ 6p$ ^1P
	-	186011.0	-	45% $5s^2\ 5p\ 6p$ ^3P
				+ 19% $5s^2\ 5p\ 6p$ ^1P
				+ 19% $5s^2\ 5p\ 6p$ ^3D
				+ 16% $5s^2\ 5p\ 6p$ ^3S
	-	193759.0	-	44% $5s^2\ 5p\ 6p$ ^3P
				+ 36% $5s^2\ 5p\ 6p$ ^1P
				+ 18% $5s^2\ 5p\ 6p$ ^3D
	-	198443.0	-	81% $5s^2\ 5p\ 6p$ ^3S
				+ 9% $5s^2\ 5p\ 6p$ ^1P
				+ 8% $5s^2\ 5p\ 6p$ ^3P
	203127.5	203101.0	26.5	91% $5s\ 5p^2\ 5d$ $((^3P)^4P)^5F$
				+ 4% $5s\ 5p^2\ 5d$ $((^3P)^4P)^5D$
	207879.2	207896.0	-16.8	54% $5s\ 5p^2\ 5d$ $((^3P)^4P)^3P$
				+ 26% $5p^4$ ^3P
				+ 10% $5s\ 5p^2\ 5d$ $((^3P)^4P)^5D$
	-	212166.0	-	52% $4f\ 5s^2\ 5p$ ^3D
				+ 34% $5s\ 5p^2\ 5d$ $((^3P)^4P)^5D$
	212890.6	213255.0	-364.4	49% $5s\ 5p^2\ 5d$ $((^3P)^4P)^5D$
				+ 40% $4f\ 5s^2\ 5p$ ^3D
	223507.9	223377.0	130.9	92% $5s\ 5p^2\ 5d$ $((^3P)^4P)^5P$
	229022.7	229198.0	-175.3	90% $5s\ 5p^2\ 6s$ $((^3P)^4P)^5P$
	237072.8	237105.0	-32.2	65% $5s\ 5p^2\ 5d$ $((^3P)^4P)^3D$
				+ 13% $5s\ 5p^2\ 5d$ $((^1S)^2S)^3D$
				+ 5% $5p^4$ ^3P
				+ 5% $5s\ 5p^2\ 5d$ $((^1D)^2D)^3D$
	238940.0	239028.0	-88.0	70% $5s\ 5p^2\ 6s$ $((^3P)^4P)^3P$
				+ 9% $5s^2\ 5^P\ 7p$ ^3P
				+ 7% $5s\ 5p^2\ 5d$ $((^1D)^2D)^3P$
				+ 4% $5s\ 5p^2\ 6s$ $((^3P)^4P)^5P$
	241394.8	241513.0	-118.2	29% $5s\ 5p^2\ 5d$ $((^1D)^2D)^3P$
				+ 23% $5p^4$ ^3P
				+ 13% $5s\ 5p^2\ 5d$ $((^3P)^2P)^3P$
				+ 7% $5s^2\ 5d^2$ ^3P
	242476.1	242671.0	-194.9	63% $5s^2\ 5p\ 7p$ ^3D
				+ 24% $5s^2\ 5p\ 7p$ ^1P
	245563.8	245231.0	332.8	38% $5s^2\ 5p\ 7p$ ^3P
				+ 23% $5s^2\ 5p\ 7p$ ^3S
				+ 14% $5s^2\ 5p\ 7p$ ^1P
				+ 11% $5s^2\ 5p\ 7p$ ^3D
	246665.4	246911.0	-245.6	76% $5s\ 5p^2\ 5d$ $((^1D)^2D)^3D$
				+ 7% $5s\ 5p^2\ 5d$ $((^1D)^2D)^3P$
				+ 7% $5s\ 5p^2\ 5d$ $((^3P)^4P)^3D$
	251275.2	250995.0	280.2	24% $5s\ 5p^2\ 5d$ $((^1D)^2D)^3P$
				+ 16% $5s\ 5p^2\ 5d$ $((^3P)^4P)^3P$
				+ 11% $5p^4$ ^3P
				+ 9% $5s^2\ 5d^2$ ^3P

	252669.2	252689.0	-19.8	27% 5s $5p^2$ 5d $((^1D)^2D)^1P$
				+ 25% 5s $5p^2$ 5d $((^3P)^2P)^1P$
				+ 12% 5s $5p^2$ 5d $((^1D)^2D)^3S$
				+ 8% 5s $5p^2$ 5d $((^3P)^2P)^3D$
	254646.8	254671.0	-24.2	41% $5s^2$ 5p 7p ^1P
				+ 32% $5s^2$ 5p 7p ^3P
				+ 13% $5s^2$ 5p 7p ^3D
	256138.4	256144.0	-5.6	65% $5s^2$ 5p 7p ^3S
				+ 16% $5s^2$ 5p 7p ^3P
				+ 9% $5s^2$ 5p 7p ^1P
				+ 8% 5s $5p^2$ 5d $((^1D)^2D)^3S$
	256849.7	256992.0	-142.3	82% $5s^2$ 5p 5f ^3D
				+ 6% 5s $5p^2$ 5d $((^1S)^2S)^3D$
				+ 4% 5s $5p^2$ 5d $((^1D)^2D)^3S$
	257877.5	257798.0	79.5	44% 5s $5p^2$ 5d $((^1D)^2D)^3S$
				+ 15% 5s $5p^2$ 6s $((^1D)^2D)^3D$
				+ 12% $5s^2$ 5p 5f ^3D
				+ 7% 5s $5p^2$ 5d $((^3P)^2P)^3D$
	259213.1	259207.0	6.1	36% 5s $5p^2$ 6s $((^1D)^2D)^3D$
				+ 22% 5s $5p^2$ 5d $((^1D)^2D)^3S$
				+ 14% 5s $5p^2$ 5d $((^1D)^2D)^1P$
				+ 6% $5s^2$ 5d 6s ^3D
	261915.1	262014.0	-98.9	26% 5s $5p^2$ 5d $((^3P)^2P)^3D$
				+ 21% 5s $5p^2$ 5d $((^1S)^2S)^3D$
				+ 20% 5s $5p^2$ 6s $((^1D)^2D)^3D$
				+ 15% 5s $5p^2$ 5d $((^1D)^2D)^1P$
	272434.8	272219.0	215.8	55% 5s $5p^2$ 5d $((^3P)^2P)^1P$
				+ 29% 5s $5p^2$ 5d $((^1D)^2D)^1P$
				+ 5% 5s $5p^2$ 5d $((^1S)^2S)^3D$
				+ 4% 5s $5p^2$ 6s $((^3P)^2P)^1P$
	279562.4	279428.0	134.4	42% 5s $5p^2$ 5d $((^3P)^2P)^3D$
				+ 34% 5s $5p^2$ 5d $((^1S)^2S)^3D$
				+ 8% 5s $5p^2$ 5d $((^3P)^4P)^3D$
				+ 6% 4f $5s^2$ 5p ^3D
	279789.1	279928.0	-138.9	43% 5s $5p^2$ 6s $((^1S)^2S)^3S$
				+ 33% 5s $5p^2$ 6s $((^3P)^2P)^3P$
				+ 8% 5s $5p^2$ 6s $((^3P)^2P)^1P$
	285492.7	285400.0	92.7	64% 5s $5p^2$ 5d $((^3P)^2P)^3P$
				+ 17% $5p^4$ ^3P
				+ 6% 5s $5p^2$ 6s $((^1S)^2S)^3S$
				+ 5% 5s $5p^2$ 5d $((^3P)^4P)^3P$
	291617.0	291550.0	67.0	51% 5s $5p^2$ 6s $((^3P)^2P)^3P$
				+ 39% 5s $5p^2$ 6s $((^1S)^2S)^3S$
	296088.2	296037.0	51.2	78% 5s $5p^2$ 6s $((^3P)^2P)^1P$
				+ 9% 5s $5p^2$ 6s $((^3P)^2P)^3P$
	302243.7	302239.0	4.7	75% $5s^2$ $5d^2$ ^3P
				+ 20% 5s $5p^2$ 5d $((^1D)^2D)^3P$
	307874.3	307932.0	-57.7	83% $5s^2$ 5d 6s ^3D
				+ 13% 5s $5p^2$ 6s $((^1D)^2D)^3D$
	399968.5	400158.0	-189.5	100% $5s^2$ 6s 6d ^3D
2	10981.5	10974.0	8.5	69% $5s^2$ $5p^2$ ^3P
				+ 29% $5s^2$ $5p^2$ ^1D
	22531.9	22450.0	81.9	68% $5s^2$ $5p^2$ ^1D
				+ 29% $5s^2$ $5p^2$ ^3P
	-	186472.0	-	69% $5s^2$ 5p 6p ^3D
				+ 15% $5s^2$ 5p 6p ^1D

			+ 15% $5s^2$ 5p 6p ^3P
-	195433.0	-	59% $5s^2$ 5p 6p ^3P
			+ 26% $5s^2$ 5p 6p ^3D
			+ 11% $5s^2$ 5p 6p ^1D
-	197679.0	-	75% 4f $5s^2$ 5p ^3F
			+ 8% 4f $5s^2$ 5p ^3D
			+ 6% 4f $5s^2$ 5p ^1D
-	199730.0	-	65% $5s^2$ 5p 6p ^1D
			+ 16% $5s^2$ 5p 6p ^3P
			+ 7% 5s $5p^2$ 5d $((^3P)^4P)^3P$
202079.9	202061.0	18.7	41% 5s $5p^2$ 5d $((^3P)^4P)^3P$
			+ 24% $5p^4$ ^3P
			+ 8% $5s^2$ 5p 6p ^3P
			+ 7% $5s^2$ 5p 6p ^1D
204517.9	204539.0	-21.1	84% 5s $5p^2$ 5d $((^3P)^4P)^5F$
			+ 7% 5s $5p^2$ 5d $((^3P)^4P)^5D$
-	210512.0	-	65% 4f $5s^2$ 5p ^3D
			+ 11% 4f $5s^2$ 5p ^3F
			+ 6% 4f $5s^2$ 5p ^1D
			+ 5% 5s $5p^2$ 5d $((^3P)^4P)^5D$
211970.2	211927.0	43.2	41% 5s $5p^2$ 5d $((^3P)^4P)^5D$
			+ 13% $5p^4$ ^1D
			+ 12% 5s $5p^2$ 5d $((^1D)^2D)^1D$
			+ 8% 4f $5s^2$ 5p ^1D
213546.6	213776.0	-229.4	32% 5s $5p^2$ 5d $((^3P)^4P)^5D$
			+ 15% 4f $5s^2$ 5p ^3D
			+ 15% $5p^4$ ^1D
			+ 14% 5s $5p^2$ 5d $((^1D)^2D)^1D$
218047.6	218241.0	-193.4	47% 5s $5p^2$ 5d $((^3P)^4P)^3F$
			+ 37% 5s $5p^2$ 5d $((^1D)^2D)^3F$
-	219887.0	-	65% 4f $5s^2$ 5p ^1D
			+ 12% $5p^4$ ^1D
			+ 10% 5s $5p^2$ 5d $((^1D)^2D)^1D$
222639.4	222544.0	95.4	87% 5s $5p^2$ 5d $((^3P)^4P)^5P$
			+ 8% 5s $5p^2$ 5d $((^3P)^4P)^5D$
234301.6	234134.0	167.6	96% 5s $5p^2$ 6s $((^3P)^4P)^5P$
235328.2	235299.0	29.2	33% 5s $5p^2$ 5d $((^3P)^4P)^3D$
			+ 19% $5p^4$ ^3P
			+ 7% 5s $5p^2$ 5d $((^3P)^2P)^3P$
			+ 6% 5s $5p^2$ 5d $((^1S)^2S)^3D$
237426.7	237244.0	182.7	23% 5s $5p^2$ 5d $((^1D)^2D)^3P$
			+ 16% $5p^4$ ^3P
			+ 16% 5s $5p^2$ 5d $((^3P)^4P)^3D$
			+ 11% 5s $5p^2$ 5d $((^3P)^2P)^3P$
241941.7	242108.0	-166.3	19% 5s $5p^2$ 5d $((^3P)^4P)^3F$
			+ 18% 5s $5p^2$ 5d $((^1D)^2D)^3F$
			+ 12% 5s $5p^2$ 5d $((^3P)^4P)^3D$
			+ 7% $5s^2$ 5p 5f ^3F
243336.5	243524.0	-187.5	34% 5s $5p^2$ 6s $((^3P)^4P)^3P$
			+ 15% $5s^2$ 5p 7p ^3D
			+ 12% $5s^2$ 5p 7p ^3P
			+ 8% $5s^2$ 5p 7p ^1D
245485.0	245588.0	-103.0	38% $5s^2$ 5p 5f ^3F
			+ 14% $5s^2$ 5p 5f ^1D
			+ 13% $5s^2$ 5p 5f ^3D
			+ 11% 5s $5p^2$ 6s $((^3P)^4P)^3P$
245855.7	246000.0	-144.3	31% $5s^2$ 5p 7p ^3D

			+ 19% $5s\ 5p^2\ 6s\ ((^3P)^4P)^3P$
			+ 13% $5s^2\ 5p\ 5f\ ^3F$
			+ 11% $5s^2\ 5p\ 7p\ ^1D$
248046.5	248136.0	-89.5	72% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3D$
			+ 11% $5s\ 5p^2\ 5d\ ((^3P)^4P)^3D$
252758.2	252976.0	-217.8	31% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3P$
			+ 19% $5s\ 5p^2\ 5d\ ((^3P)^4P)^3P$
			+ 12% $5s^2\ 5d^2\ ^3P$
			+ 11% $5s\ 5p^2\ 6s\ ((^3P)^4P)^3P$
254855.7	255046.0	-190.3	33% $5s^2\ 5p\ 7p\ ^3D$
			+ 30% $5s^2\ 5p\ 7p\ ^1D$
			+ 22% $5s^2\ 5p\ 7p\ ^3P$
			+ 8% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
256447.6	256237.0	210.6	46% $5s^2\ 5p\ 5f\ ^3D$
			+ 31% $5s^2\ 5p\ 5f\ ^3F$
			+ 8% $5s^2\ 5p\ 5f\ ^1D$
			+ 4% $5s^2\ 5p\ 7p\ ^3P$
256720.4	256663.0	57.4	51% $5s^2\ 5p\ 7p\ ^3P$
			+ 27% $5s^2\ 5p\ 7p\ ^1D$
			+ 7% $5s^2\ 5p\ 5f\ ^3D$
			+ 6% $5s\ 5p^2\ 6s\ ((^1D)^2D)^1D$
257862.0	257974.0	-112.0	32% $5s^2\ 5p\ 5f\ ^1D$
			+ 21% $5s^2\ 5p\ 5f\ ^3D$
			+ 16% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
			+ 7% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3D$
258643.7	258816.0	-172.3	25% $5s^2\ 5^P\ 5f\ ^1D$
			+ 23% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
			+ 14% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 9% $5s^2\ 5^P\ 7p\ ^1D$
262306.2	262207.0	99.2	36% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3F$
			+ 9% $5s\ 5p^2\ 6s\ ((^1D)^2D)^1D$
			+ 8% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 6% $5s^2\ 5p\ 5f\ ^1D$
263399.1	263575.0	-175.9	24% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
			+ 21% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3D$
			+ 19% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 7% $5s\ 5p^2\ 5d\ ((^1S)^2S)^1D$
264449.0	264463.0	-14.0	43% $5s\ 5p^2\ 6s\ ((^1D)^2D)^1D$
			+ 21% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3F$
			+ 6% $5s^2\ 5d\ 6s$ 1D
			+ 5% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3D$
269870.5	269703.0	167.5	19% $5s\ 5p^2\ 6s\ ((^1D)^2D)^1D$
			+ 17% $5s\ 5p^2\ 5d\ ((^1D)^2D)^1D$
			+ 17% $5s\ 5p^2\ 5d\ ((^1S)^2S)^1D$
			+ 16% $5s^2\ 5d^2\ ^1D$
276924.1	276536.0	388.1	25% $5s\ 5p^2\ 5d\ ((^1S)^2S)^1D$
			+ 15% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 13% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3P$
			+ 12% $5p^4\ ^1D$
277621.0	277922.0	-301.0	42% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3D$
			+ 16% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 15% $5s\ 5p^2\ 5d\ ((^1S)^2S)^1D$
			+ 8% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3P$
282821.8	283008.0	-186.2	50% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3P$
			+ 13% $5p^4\ ^3P$
			+ 10% $5s\ 5p^2\ 5d\ ((^1S)^2S)^1D$
			+ 7% $5s^2\ 5d^2\ ^1D$

	293224.0	293328.0	-104.0	91% 5s 5p^2 6s ((^{3}P)^{2}P)^{3}P
	294012.4	293965.0	47.4	66% 5s^2 5d^2 ^{3}F
				+ 16% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
				+ 9% 5s 5p^2 5d ((^{3}P)^{2}P)^{1}D
	299224.3	298985.0	239.3	66% 5s 5p^2 5d ((^{3}P)^{2}P)^{1}D
				+ 6% 5s^2 5d^2 ^{3}F
				+ 5% 5s^2 5d^2 ^{1}D
				+ 5% 5s 5p^2 5d ((^{18})^{2}S)^{1}D
	303078.5	303368.0	-289.5	69% 5s^2 5d^2 ^{3}P
				+ 20% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}P
	304423.3	304375.0	48.3	34% 5s^2 5d^2 ^{1}D
				+ 22% 5s 5p^2 5d ((^{1}D)^{2}D)^{1}D
				+ 19% 5s^2 5d 6s ^{1}D
				+ 9% 5p^4 ^{1}D
	308117.1	308224.0	-106.9	85% 5s2 5d 6s ^{3}D
				+ 13% 5s 5p2 6s ((^{1}D)^{2}D)^{3}D
	316942.5	316958.0	-15.5	64% 5s^2 5d 6s ^{1}D
				+ 17% 5s^2 5d^2 ^{1}D
				+ 9% 5s 5p2 6s ((^{1}D)^{2}D)^{1}D
				+ 5% 5s 5p2 5d ((^{1}D)^{2}D)^{1}D
	400569.4	400304.0	265.4	98% 5s^2 6s 6d ^{3}D
	402184.6	402188.0	-3.4	98% 5s^2 6s 6d ^{1}D
3	-	194827.0	-	47% 4f 5s^2 5p ^{1}F
				+ 37% 4f 5s^2 5p ^{3}G
				+ 5% 4f 5s^2 5p ^{3}D
				+ 4% 5s^2 5p 6p ^{3}D
	-	195812.0	-	53% 5s^2 5p 6p ^{3}D
				+ 20% 4f 5s^2 5p ^{3}F
				+ 13% 4f 5s^2 5p ^{3}G
				+ 8% 4f 5s^2 5p ^{3}D
	-	196952.0	-	40% 5s^2 5p 6p ^{3}D
				+ 30% 4f 5s^2 5p ^{3}F
				+ 11% 4f 5s^2 5p ^{1}F
				+ 7% 4f 5s^2 5p ^{3}D
	-	204455.0	-	31% 4f 5s^2 5p ^{3}G
				+ 27% 4f 5s^2 5p ^{1}F
				+ 21% 4f 5s^2 5p ^{3}F
				+ 10% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}F
	206673.7	206582.0	91.7	70% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}F
				+ 14% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
				+ 7% 4f 5s^2 5p ^{3}F
				+ 4% 4f 5s^2 5p ^{3}G
	-	209229.0	-	67% 4f 5s^2 5p ^{3}D
				+ 13% 4f 5s^2 5p ^{3}F
				+ 5% 4f 5s^2 5p ^{1}F
	213131.4	213065.0	66.4	57% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
				+ 14% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}F
				+ 13% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}P
				+ 6% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
	220100.1	220175.0	-74.9	53% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}P
				+ 20% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
				+ 20% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}F
	221879.7	221816.0	63.7	28% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}P
				+ 24% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}F
				+ 22% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
				+ 19% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F

238152.6	238089.0	63.6	55% $5s\ 5p^2\ 5d\ ((^3P)^4P)^3D$
			+ 8% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3D$
			+ 7% $5s\ 5p^2\ 5d\ ((^3P)^4P)^3F$
			+ 6% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3F$
239200.1	239162.0	38.1	90% $5s\ 5p^2\ 6s\ ((^3P)^4P)^5P$
			+ 6% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
242648.8	242396.0	252.8	21% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3F$
			+ 18% $5s\ 5p^2\ 5d\ ((^3P)^4P)^3F$
			+ 15% $5s\ 5p^2\ 5d\ ((^1D)^2D)^1F$
			+ 10% $5s^2\ 5p\ 5f\ ^3F$
243026.9	242840.0	186.9	31% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3G$
			+ 31% $5s^2\ 5p\ 5f\ ^3G$
			+ 11% $5s\ 5p^2\ 5d\ ((^1D)^2D)^1F$
			+ 10% $5s^2\ 5p\ 5f\ ^1F$
244963.9	245109.0	-145.1	36% $5s^2\ 5p\ 5f\ ^3D$
			+ 27% $5s^2\ 5p\ 5f\ ^1F$
			+ 21% $5s^2\ 5p\ 5f\ ^3F$
246925.1	246559.0	366.1	21% $5s^2\ 5p\ 5f\ ^3G$
			+ 19% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3D$
			+ 16% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3G$
			+ 13% $5s\ 5p^2\ 5d\ ((^1D)^2D)^1F$
247840.1	247992.0	-151.9	34% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3G$
			+ 27% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3D$
			+ 16% $5s\ 5p^2\ 5d\ ((^1D)^2D)^1F$
			+ 5% $5s^2\ 5p\ 5f\ ^3G$
251631.0	251560.0	71.0	27% $5s\ 5p^2\ 5d\ ((^1D)^2D)^3D$
			+ 22% $5s\ 5p^2\ 5d\ ((^3P)^4P)^3D$
			+ 22% $5s\ 5p^2\ 5d\ ((^1D)^2D)^1F$
			+ 5% $5s\ 5p^2\ 5d\ ((^3P)^4P)^3F$
255097.6	255067.0	30.6	45% $5s^2\ 5p\ 5f\ ^1F$
			+ 30% $5s^2\ 5p\ 5f\ ^3G$
			+ 16% $5s^2\ 5p\ 5f\ ^3F$
255588.7	255390.0	198.7	80% $5s^2\ 5p\ 7p\ ^3D$
			+ 7% $5s\ 5p2\ 6s\ ((^1D)^2D)^3D$
			+ 5% $5s^2\ 5p\ 5f\ ^3D$
256015.1	256151.0	-135.9	44% $5s^2\ 5p\ 5f\ ^3D$
			+ 32% $5s^2\ 5p\ 5f\ ^3F$
			+ 7% $5s^2\ 5p\ 7p\ ^3D$
			+ 6% $5s^2\ 5p\ 5f\ ^1F$
260690.7	260444.0	246.7	52% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
			+ 13% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 9% $5s^2\ 5d\ 6s\ ^3D$
			+ 7% $5s^2\ 5p\ 7p\ ^3D$
263441.0	263752.0	-311.0	46% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3F$
			+ 17% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 11% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
269518.6	269525.0	-6.4	39% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 28% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3D$
			+ 16% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3F$
			+ 5% $5s\ 5p^2\ 6s\ ((^1D)^2D)^3D$
274983.9	275116.0	-132.1	56% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3D$
			+ 13% $5s\ 5p^2\ 5d\ ((^3P)^2P)^3F$
			+ 12% $5s\ 5p^2\ 5d\ ((^1S)^2S)^3D$
			+ 4% $5s^2\ 5d^2\ ^3F$
288866.9	289087.0	-220.1	80% $5s\ 5p^2\ 5d\ ((^3P)^2P)^1F$
			+ 10% $5s\ 5p^2\ 5d\ ((^1D)^2D)^1F$
294725.5	294953.0	-227.5	73% $5s^2\ 5d^2\ ^3F$

				+ 19% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
	308912.4	308748.0	164.4	86% 5s^2 5d 6s ^{3}D
				+ 12% 5s 5p^2 6s ((^{1}D)^{2}D)^{3}D
	400509.2	400582.0	-72.8	100% 5s^2 6s 6d ^{3}D
4	-	197571.0	-	43% 4f 5s^2 5p ^{3}G
				+ 42% 4f 5s^2 5p ^{3}F
				+ 6% 4f 5s^2 5p ^{1}G
				+ 4% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}G
	-	205388.0	-	45% 4f 5s^2 5p ^{3}F
				+ 39% 4f 5s^2 5p ^{3}G
				+ 7% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}F
				+ 5% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}G
	209633.8	209783.0	-149.2	79% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}F
				+ 13% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
	215186.7	215048.0	138.7	67% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
				+ 11% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
				+ 11% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}F
				+ 6% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}F
	-	215697.0	-	81% 4f 5s^2 5p ^{1}G
				+ 7% 5s^2 5d^2 ^{1}G
				+ 4% 4f 5s^2 5p ^{3}G
	225322.3	225323.0	-0.7	38% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}F
				+ 35% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
				+ 16% 5s 5p^2 5d ((^{3}P)^{4}P)^{5}D
				+ 5% 5s^2 5d^2 ^{3}F
	239419.2	239398.0	21.2	51% 5s 5p^2 5d ((^{1}D)^{2}D)^{1}G
				+ 14% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
				+ 8% 5s^2 5d^2 ^{1}G
				+ 6% 5s^2 5p 5f ^{1}G
	244976.3	244795.0	181.3	30% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}G
				+ 25% 5s^2 5p 5f ^{3}G
				+ 16% 5s^2 5p 5f ^{3}F
				+ 14% 5s 5p^2 5d ((^{1}D)^{2}D)^{1}G
	246749.7	247078.0	-328.3	34% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}F
				+ 16% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
				+ 14% 5s^2 5p 5f ^{1}G
				+ 13% 5s^2 5p 5f ^{3}G
	247915.3	247893.0	22.3	50% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}G
				+ 20% 5s^2 5p 5f 3F
				+ 7% 5s 5p^2 5d ((^{3}P)^{4}P)^{3}F
				+ 6% 5s 5p^2 5d ((^{1}D)^{2}D)^{1}G
	255667.7	255838.0	-170.3	52% 5s^2 5p 5f ^{3}F
				+ 39% 5s^2 5p 5f ^{3}G
	258965.1	258692.0	273.1	72% 5s^2 5p 5f ^{1}G
				+ 16% 5s^2 5p 5f ^{3}G
				+ 6% 5s^2 5p 5f ^{3}F
				+ 4% 5s 5p^2 5d ((^{1}D)^{2}D)^{1}G
	270086.9	269920.0	166.9	85% 5s 5p^2 5d ((^{3}P)^{2}P)^{3}F
				+ 4% 5s^2 5d^2 ^{3}F
	295332.4	295197.0	135.4	77% 5s^2 5d^2 ^{3}F
				+ 18% 5s 5p^2 5d ((^{1}D)^{2}D)^{3}F
	303052.1	303042.0	10.1	79% 5s^2 5d^2 ^{1}G
				+ 15% 5s 5p^2 5d ((^{1}D)^{2}D)^{1}G
				+ 5% 4f 5s^2 5p ^{1}G
5	-	206071.0	-	82% 4f 5s^2 5p ^{3}G

			+ 12% 5s $5p^2$ 5d $((^1D)\,^2D)\,^3G$
			+ 5% 5s $5p^2$ 5d $((^3P)\,^4P)\,^5F$
-	213844.0	-	93% 5s $5p^2$ 5d $((^3P)\,^4P)\,^5F$
			+ 7% 4f $5s^2$ 5p ^3G
-	248078.0	-	81% 5s $5p^2$ 5d $((^1D)\,^2D)\,^3G$
			+ 11% 4f $5s^2$ 5p 3G
			+ 6% $5s^2$ 5p 5f ^3G
-	256940.0	-	94% $5s^2$ 5p 5f ^3G
			+ 6% 5s $5p^2$ 5d $((^1D)\,^2D)\,^3G$

Table 4.4. Least Squares Fitted energy parameters (in cm^{-1}) for odd parity configurations of I IV

Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$5s\,5p^3$	E_{av} $(5s\,5p^3)$	116375.9	112.0	114214.7	1.018
	F^2(5p, 5p)	41288.3	483.0	50917.5	0.811
	α_{5p}	-175.0	-37.0		
	ζ_{5p}	7796.0	173.0	6953.1	1.121
	G1(5s, 5p)	44718.1	187.0	66735.7	0.670
$5s^2\,5p\,5d$	E_{av} $(5s^2\,5p\,5d)$	143919.5	106.0	144864.3	0.990
	ζ_{5p}	7377.1	137.0	7277.7	1.014
	ζ_{5d}	512.4	77.0	393.9	1.301
	F^2(5p, 5d)	32554.9	592.0	37505.9	0.868
	G^1(5p, 5d)	29828.0	293.0	41968.9	0.711
	G^3(5p, 5d)	21125.5	590.0	26453.4	0.799
$5s^2\,5p\,6d$	E_{av} $(5s^2\,5p\,6d)$	231005.6	52.0	231063.0	0.998
	ζ_{5p}	7929.0	75.0	7628.3	1.039
	ζ_{6d}	152.0	(fixed)	147.3	1.032
	F^2(5p, 6d)	10187.2	549.0	11804.1	0.863
	G^1(5p, 6d)	5487.0	(fixed)	7839.3	0.700
	G^3(5p, 6d)	3869.0	(fixed)	5526.8	0.700
$5s^2\,5p\,7d$	E_{av} $(5s^2\,5p\,7d)$	268212.2	53.0	268099.3	0.999
	ζ_{5p}	7999.8	73.0	7683.2	1.041
	ζ_{7d}	80.0	(fixed)	74.1	1.080
	F^2(5p, 7d)	3854.1	558.0	5357.7	0.719
	G^1(5p, 7d)	2186.8	311.0	3151.1	0.694
	G^3(5p, 7d)	1603.6	228.0	2311.4	0.694
$5s^2\,5p\,6s$	E_{av} $(5s^2\,5p\,6s)$	157460.2	95.0	157868.2	0.995
	ζ_{5p}	7527.6	120.0	7509.0	1.002
	G^1(5p, 6s)	4150.0	(fixed)	5928.3	0.700
$5s^2\,5p\,7s$	E_{av} $(5s^2\,5p\,7s)$	234867.5	96.0	234442.9	1.000
	ζ_{5p}	8096.8	118.0	7653.4	1.058
	G^1(5p, 7s)	1266.0	(fixed)	1809.3	0.700
$5s^2\,5p\,8s$	E_{av} $(5s^2\,5p\,8s)$	270246.9	91.0	269482.0	1.002
	ζ_{5p}	8077.7	114.0	7692.7	1.050
	G^1(5p, 8s)	587.0	(fixed)	837.7	0.701
$5s\,5p^3$ $-5s^2\,5p\,5d$	R^1(5p, 5p; 5s, 5d)	35264.1	278.0	50669.8	0.696
$5s\,5p^3$ $-5s^2\,5p\,6d$	R^1(5p, 5p; 5s, 6d)	15270.5	120.0	21945.9	0.696
$5s\,5p^3$ $-5s^2\,5p\,7d$	R^1(5p, 5p; 5s, 7d)	10923.5	(fixed)	13654.4	0.800
$5s\,5p^3$ $-5s^2\,5p\,6s$	R^1(5p, 5p; 5s, 6s)	-1094.0	-9.0	-1572.4	0.696
$5s\,5p^3$ $-5s^2\,5p\,7s$	R^1(5p, 5p; 5s, 7s)	-1090.0	-9.0	-1566.8	0.696

$5s\,5p^3$ -5s2 5p 8s	R^1(5p, 5p; 5s, 8s)	-1016.0	(fixed)	-1269.9	0.800
$5s^2$ 5p 5d -$5s^2$ 5p 6d	R^2(5p, 5d; 5p, 6d)	8182.3	64.0	11757.3	0.696
	R^1(5p, 5d; 6d, 5p)	11735.4	92.0	16861.9	0.696
	R^3(5p, 5d; 6d, 5p)	7718.2	61.0	11090.0	0.696
$5s^2$ 5p 5d -$5s^2$ 5p 7d	R^2(5p, 5d; 5p, 7d)	5206.1	(fixed)	6507.7	0.800
	R^1(5p, 5d; 7d, 5p)	8137.1	(fixed)	10171.4	0.800
	R^3(5p, 5d; 7d, 5p)	5362.2	(fixed)	6702.7	0.800
$5s^2$ 5p 5d -$5s^2$ 5p 6s	R^2(5p, 5d; 5p, 6s)	-9054.3	-71.0	-13010.1	0.696
	R^1(5p, 5d; 6s, 5p)	-3704.1	-29.0	-5322.0	0.696
$5s^2$ 5p 5d -$5s^2$ 5p 7s	R^2(5p, 5d; 5p, 7s)	-4577.1	-36.0	-6577.0	0.696
	R^1(5p, 5d; 7s, 5p)	-2387.1	-19.0	-3430.3	0.696
$5s^2$ 5p 5d -$5s^2$ 5p 8s	R^2(5p, 5d; 5p, 8s)	-3491.9	(fixed)	-4364.9	0.800
	R^1(5p, 5d; 8s, 5p)	-1960.8	(fixed)	-2451.0	0.800
$5s^2$ 5p 6d -$5s^2$ 5p 7d	R^2(5p, 6d; 5p, 7d)	4989.7	(fixed)	6237.2	0.800
	R^1(5p, 6d; 7d, 5p)	3948.3	(fixed)	4935.4	0.800
	R^3(5p, 6d; 7d, 5p)	2831.3	(fixed)	3539.	0.800
$5s^2$ 5p 6d -$5s^2$ 5p 6s	R^2(5p, 6d; 5p, 6s)	3110.1	24.0	4469.4	0.696
	R^1(5p, 6d; 6s, 5p)	-21.0	0.0	-30.8	0.682
$5s^2$ 5p 6d -$5s^2$ 5p 7s	R^2(5p, 6d; 5p, 7s)	-2325.1	-18.0	-3340.6	0.696
	R^1(5p, 6d; 7s, 5p)	-345.0	-3.0	-496.0	0.696
$5s^2$ 5p 6d -$5s^2$ 5p 8s	R^2(5p, 6d; 5p, 8s)	-1775.6	(fixed)	-2219.5	0.800
	R^1(5p, 6d; 8s, 5p)	-371.5	(fixed)	-464.4	0.800
$5s^2$ 5p 7d -$5s^2$ 5p 6s	R^2(5p, 7d; 5p, 6s)	3350.7	(fixed)	4188.4	0.800
	R^1(5p, 7d; 6s, 5p)	377.8	(fixed)	472.2	0.800
$5s^2$ 5p 7d -$5s^2$ 5p 7s	R^2(5p, 7d; 5p, 7s)	440.7	(fixed)	550.9	0.800
	R^1(5p, 7d; 7s, 5p)	-43.4	(fixed)	-54.3	0.800
$5s^2$ 5p 7d -$5s^2$ 5p 8s	R^2(5p, 7d; 5p, 8s)	-1034.8	(fixed)	-1293.5	0.800
	R^1(5p, 7d; 8s, 5p)	-100.9	(fixed)	-126.1	0.800
$5s^2$ 5p 6s -$5s^2$ 5p 7s	R^1(5p, 6s; 7s, 5p)	2168.1	17.0	3115.1	0.696
$5s^2$ 5p 6s -$5s^2$ 5p 8s	R^1(5p, 6s; 8s, 5p)	1631.0	(fixed)	2038.8	0.800
$5s^2$ 5p 7s -$5s^2$ 5p 8s	R^1(5p, 7s; 8s, 5p)	978.9	(fixed)	1223.6	0.800
	σ	148			

Table 4.5. Least Squares Fitted energy parameters (in cm^{-1}) for even parity configurations of I IV

Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$5s^2\,5p^2$	E_{av} ($5s^2\,5p^2$)	21595.7	119.0	20368.0	.
	F^2(5p, 5p)	42848.7	595.0	50903.1	0.842
	α_{5p}	-100.3	(fixed)		
	ζ_{5p}	7587.3	127.0	6989.4	1.086
$5s\,5p^2\,5d$	E_{av} ($5s\,5p^2\,5d$)	242893.5	42.0	244550.4	0.987
	F^2(5p, 5p)	44071.0	496.0	51650.3	0.853
	α_{5p}	-153.7	-33.0		
	ζ_{5p}	-153.7	88.0	7225.9	0.997
	ζ_{5d}	413.2	(fixed)	413.2	1.000
	F^2(5p, 5d)	32910.1	363.0	38191.5	0.862
	G^1(5s, 5p)	47669.9	150.0	67601.8	0.705
	G^2(5s, 5d)	20417.5	486.0	26614.3	0.767
	G^1(5p, 5d)	30507.3	185.0	43150.9	0.707
	G^3(5p, 5d)	21201.8	434.0	27201.7	0.779
$5s\,5p^2\,6s$	E_{av} ($5s\,5p^2\,6s$)	261191.4	100.0	260604.9	0.997
	F^2(5p, 5p)	45449.7	558.0	52225.4	0.870
	α_{5p}	-193.4	-63.0		
	ζ_{5p}	7754.1	114.0	7463.1	1.039
	G^1(5s, 5p)	50008.2	214.0	68254.7	0.733
	G^0(5s, 6s)	2596.8	127.0	3850.3	0.674
	G^1(5p, 6s)	4067.2	230.0	5991.1	0.679
$5p^4$	E_{av} (5p4)	241531.9	301.0	239480.5	1.004
	F^2(5p, 5p)	43078.4	1012.0	50948.4	0.846
	α_{5p}	-200.0	(fixed)		
	ζ_{5p}	6924.1	(fixed)	6924.1	1.000
$5s^2\,5p\,6p$	E_{av} ($5s^2\,5p\,6p$)	194571.8	(fixed)	194565.0	0.993
	ζ_{5p}	7639.2	(fixed)	7639.3	1.000
	ζ_{6p}	1782.8	(fixed)	1782.9	1.000
	F^2(5p, 6p)	14172.9	(fixed)	16674.0	0.850
	G^0(5p, 6p)	2815.2	(fixed)	3753.7	0.750
	G^2(5p, 6p)	3627.4	(fixed)	4836.7	0.750
$5s^2\,5p\,7p$	E_{av} ($5s^2\,5p\,7p$)	252495.9	78.0	253834.1	0.989
	ζ_{5p}	7754.9	110.0	7686.7	1.009
	ζ_{7p}	806.1	(fixed)	806.2	1.000
	F^2(5p, 7p)	5489.2	527.0	6894.7	0.796
	G^0(5p, 7p)	999.6	84.0	1273.4	0.785
	G^2(5p, 7p)	1411.5	118.0	1798.1	0.785
$4f\,5s^2\,5p$	E_{av} ($4f\,5s^2\,5p$)	210135.7	(fixed)	203212.3	1.031
	ζ_{4f}	48.5	(fixed)	48.5	1.000
	ζ_{5p}	7160.9	(fixed)	7161.0	1.000

	F^2(4f, 5p)	32200.5	(fixed)	37883.0	1.000
	G^2(4f, 5p)	23948.2	(fixed)	31931.0	0.750
	G^4(4f, 5p)	16358.1	(fixed)	21810.8	0.750
$5s^2$ 5p 5f	E_{av} ($5s^2$ 5p 5f)	252688.4	86.0	252495.4	0.996
	ζ_{5p}	7481.5	127.0	7499.7	0.998
	ζ_{5f}	30.9	(fixed)	31.0	0.997
	F^2(5p, 5f)	10574.5	1000.0	14008.1	0.755
	G^2(5p, 5f)	4749.8	949.0	7172.5	0.662
	G^4(5p, 5f)	4112.6	(fixed)	5483.5	0.750
$5s^2$ $6s^2$	E_{av} ($5s_2$ $6s^2$)	323300.4	318.0	324724.5	0.991
$5s^2$ $5d^2$	E_{av} ($5s^2$ $5d^2$)	286310.9	222.0	289498.8	0.984
	F^2(5d, 5d)	28398.3	797.0	37422.0	0.759
	F^4(5d, 5d)	21514.7	(fixed)	25311.5	0.850
	α_{5d}	-195.5	-17.0		
	ζ_{5d}	419.1	(fixed)	419.2	1.000
$5s^2$ 5d 6s	E_{av} ($5s^2$ 5d 6s)	302786.5	179.0	303501.3	0.993
	ζ_{5d}	447.4	(fixed)	447.4	1.000
	G^2(5d, 6s)	10714.2	836.0	17018.3	0.630
$5s^2$ 6s 6d	E_{av} ($5s^2$ 6s 6d	400382.0	97.0	400717.6	0.996
	ζ_{6d}	168.7	(fixed)	168.8	0.999
	G^2(6s, 6d)	4577.7	569.0	7348.0	0.623
$5s^2$ $5p^2$ -5s $5p^2$ 5d	R^1(5s, 5p; 5p, 5d)	42732.1	295.0	51919.3	0.823
	R^2(5s, 5p; 5d, 5p)	30528.1	211.0	37091.4	0.823
$5s^2$ $5p^2$ -5s $5p^2$ 6s	R^0(5s, 5s; 5s, 6s)	2778.5	19.0	3375.9	0.823
	R^1(5s, 5p; 5p, 6s)	-769.4	-5.0	-934.8	0.823
	R^0(5s, 5p; 6s, 5p)	-52.5	0.0	-63.7	0.824
$5s^2$ $5p^2$ -$5p^4$	R^1(5s, 5s; 5p, 5p)	53474.9	(fixed)	66843.6	0.800
$5s^2$ $5p^2$ -$5s^2$ 5p 6p	R^0(5p, 5p; 5p, 6p)	1383.4	(fixed)	1729.3	0.800
	R^2(5p, 5p; 5p, 6p)	6459.2	(fixed)	8074.0	0.800
$5s^2$ $5p^2$ -$5s^2$ 5p 7p	R^0(5p, 5p; 5p, 7p)	690.4	(fixed)	863.0	0.800
	R^2(5p, 5p; 5p, 7p)	2929.7	(fixed)	3662.1	0.800
$5s^2$ $5p^2$ -4f $5s^2$ 5p	R^2(5p, 5p; 4f, 5p)	-31352.4	(fixed)	-39190.5	0.800
$5s^2$ $5p^2$ -$5s^2$ 5p 5f	R^2(5p, 5p; 5p, 5f)	-14272.1	-98.0	-17340.5	0.823
$5s^2$ $5p^2$ -$5s^2$ $6s^2$	R^1(5p, 5p; 6s, 6s)	6092.4	42.0	7402.2	0.823
$5s^2$ $5p^2$ -$5s^2$ $5d^2$	R^1(5p, 5p; 5d, 5d)	36499.0	252.0	44346.2	0.823
	R^3(5p, 5p; 5d, 5d)	22997.1	159.0	27941.4	0.823
$5s^2$ $5p^2$ -$5s^2$ 5d 6s	R^1(5p, 5p; 5d, 6s)	-5940.1	-41.0	-7217.1	0.823
$5s^2$ $5p^2$ -$5s^2$ 6s 6d	R^1(5p, 5p; 6s, 6d	-654.3	-5.0	-795.0	0.823
5s $5p^2$ 5d -5s $5p^2$ 6s	R^2(5p, 5d; 5p, 6s)	-10164.7	-70.0	-12350.0	0.823
	R^1(5p, 5d; 6s, 5p)	-3914.6	-27.0	-4756.3	0.823
5s $5p^2$ 5d -$5p^4$	R^1(5s, 5d; 5p, 5p)	41114.9	(fixed)	51393.6	0.800
5s $5p^2$ 5d -$5s^2$ 5p 6p	R^1(5p, 5d; 5s, 6p)	-4049.8	(fixed)	-5062.3	0.800
	R^2(5p, 5d; 6p, 5s)	3873.1	(fixed)	4841.3	0.800
5s $5p^2$ 5d -$5s^2$ 5p 7p	R^1(5p, 5d; 5s, 7p)	-2271.6	(fixed)	-2839.5	0.800
	R^2(5p, 5d; 7p, 5s)	1573.2	(fixed)	1966.4	0.800
5s $5p^2$ 5d -4f $5s^2$ 5p	R^2(5p, 5d; 4f, 5s)	-23598.5	-163.0	-28672.0	0.823

	R^1(5p, 5d; 5s, 4f)	-34634.6	-239.0	-42080.8	0.823
5s 5p^2 5d -5s^2 5p 5f	R^1(5p, 5d; 5s, 5f)	-7447.3	-51.0	-9048.3	0.823
	R^2(5p, 5d; 5f, 5s)	-9920.8	-68.0	-12053.7	0.823
5s 5p^2 5d -5s^2 5d2	R^1(5p, 5p; 5s, 5d)	42617.4	294.0	51779.9	0.823
5s 5p^2 5d -5s^2 5d 6s	R^1(5p, 5p; 5s, 6s)	-1258.6	-9.0	-1529.3	0.823
5s 5p^2 6s -5p^4	R^1(5s, 6s; 5p, 5p)	-552.4	(fixed)	-690.4	0.800
5s 5p^2 6s -5s^2 5p 6p	R^1(5p, 6s; 5s, 6p)	21464.9	(fixed)	26831.2	0.800
	R^0(5p, 6s; 6p, 5s)	2814.1	(fixed)	3517.6	0.800
5s 5p^2 6s -5s^2 5p 7p	R^1(5p, 6s; 5s, 7p)	9906.5	(fixed)	12383.2	0.800
	R^0(5p, 6s; 7p, 5s)	1694.7	(fixed)	2118.4	0.800
5s 5p^2 6s -5s^2 6s^2	R^1(5p, 5p; 5s, 6s)	-1391.5	-10.0	-1690.6	0.823
5s 5p^2 6s -5s^2 5d 6s	R^1(5p, 5p; 5s, 5d)	43420.2	300.0	52755.3	0.823
5s 5p^2 6s -5s^2 6s 6d	R^1(5p, 5p; 5s, 6d)	18500.0	128.0	22477.4	0.823
5s^2 5p 6p -5s^2 5p 7p	R^2(5p, 6p; 5p, 7p)	5795.6	(fixed)	7244.5	0.800
	R^0(5p, 6p; 7p, 5p)	1726.3	(fixed)	2157.9	0.800
	R^2(5p, 6p; 7p, 5p)	2301.3	(fixed)	2876.6	0.800
5s^2 5p 6p -4f 5s^2 5p	R^2(5p, 6p; 4f, 5p)	-3932.9	-27.0	-4778.3	0.823
	R^2(5p, 6p; 5p, 4f)	150.7	1.0	183.1	0.823
5s^2 5p 6p -5s^2 5p 5f	R^2(5p, 6p; 5p, 5f)	-8607.4	-59.0	-10458.0	0.823
	R^2(5p, 6p; 5f, 5p)	-3388.1	-23.0	-4116.5	0.823
5s^2 5p 6p -5s^2 6s^2	R^1(5p, 6p; 6s, 6s)	-6794.0	(fixed)	-8492.5	0.800
5s^2 5p 6p -5s^2 5d^2	R^1(5p, 6p; 5d, 5d)	-6706.1	(fixed)	-8382.6	0.800
	R^3(5p, 6p; 5d, 5d)	-2684.6	(fixed)	-3355.8	0.800
5s^2 5p 6p -5s^2 5d 6s	R^1(5p, 6p; 5d, 6s)	20717.0	(fixed)	25896.3	0.800
	R^1(5p, 6p; 6s, 5d)	5230.5	(fixed)	6538.1	0.800
5s^2 5p 6p -5s^2 6s 6d	R^1(5p, 6p; 6s, 6d)	-4478.6	(fixed)	-5598.2	0.800
	R^1(5p, 6p; 6d, 6s)	5759.4	(fixed)	7199.3	0.800
5s^2 5p 7p -4f 5s^2 5p	R^2(5p, 7p; 4f, 5p)	-1508.5	(fixed)	-1885.6	0.800
	R^2(5p, 7p; 5p, 4f)	-56.2	(fixed)	-70.3	0.800
5s^2 5p 7p -5s^2 5p 5f	R^2(5p, 7p; 5p, 5f)	-1904.3	(fixed)	-2380.4	0.800
	R^2(5p, 7p; 5f, 5p)	-1656.4	(fixed)	-2070.4	0.800
5s2 5p 7p -5s2 6s2	R^1(5p, 7p; 6s, 6s)	-2318.1	(fixed)	-2897.6	0.800
5s2 5p 7p -5s2 5d2	R^1(5p, 7p; 5d, 5d)	-3647.8	(fixed)	-4559.8	0.800
	R^3(5p, 7p; 5d, 5d)	-2157.3	(fixed)	-2696.7	0.800
5s^2 5p 7p -5s^2 5d 6s	R^1(5p, 7p; 5d, 6s)	9134.2	(fixed)	11417.8	0.800
	R^1(5p, 7p; 6s, 5d)	2729.3	(fixed)	3411.7	0.800
5s^2 5p 7p -5s^2 6s 6d	R^1(5p, 7p; 6s, 6d)	1384.1	(fixed)	1730.1	0.800
	R^1(5p, 7p; 6d, 6s)	3181.6	(fixed)	3976.9	0.800
4f 5s^2 5p -5s^2 5p 5f	R^2(4f, 5p; 5p, 5f)	11273.7	78.0	13697.4	0.823
	R^4(4f, 5p; 5p, 5f)	8070.6	56.0	9805.8	0.823
	R^0(4f, 5p; 5f, 5p)	743.6	5.0	903.5	0.823
	R^2(4f, 5p; 5f, 5p)	11498.5	79.0	13970.6	0.823
4f 5s^2 5p -5s^2 5d^2	R^1(4f, 5p; 5d, 5d)	-31656.1	-218.0	-38462.0	0.823
	R^3(4f, 5p; 5d, 5d)	-19936.2	-138.0	-24222.4	0.823
4f 5s^2 5p -5s^2 5d 6s	R^1(4f, 5p; 5d, 6s)	7734.2	53.0	9397.1	0.823
	R^1(4f, 5p; 5d, 6s)	7578.3	52.0	9207.6	0.823

$4f\,5s^2\,5p$ - $5s^2\,6s\,6d$	R^3(4f, 5p; 6s, 6d)	486.1	3.0	590.7	0.823
	R^1(4f, 5p; 6d, 6s)	-1377.9	-10.0	-1674.2	0.823
$5s^2\,5p\,5f$ - $5s^2\,5d^2$	R^1(5p, 5f; 5d, 5d)	-5302.9	-37.0	-6443.0	0.823
	R^3(5p, 5f; 5d, 5d)	-4948.5	-34.0	-6012.4	0.823
$5s^2\,5p\,5f$ - $5s^2\,5d\,6s$	R^3(5p, 5f; 5d, 6s)	-3248.3	-22.0	-3946.6	0.823
	R^1(5p, 5f; 6s, 5d)	-594.5	-4.0	-722.3	0.823
$5s^2\,5p\,5f$ - $5s^2\,6s\,6d$	R^1(5p, 5f; 6s, 6d)	4827.6	33.0	5865.5	0.823
	R^3(5p, 5f; 6d, 6s)	-450.5	-3.0	-547.4	0.823
$5s^2\,6s^2$ - $5s^2\,5d^2$	R^2(6s, 6s; 5d, 5d)	15316.1	106.0	18609.0	0.823
$5s^2\,5d^2$ - $5s^2\,5d\,6s$	R^2(5d, 5d; 5d, 6s)	-17159.9	-118.0	-20849.1	0.823
$5s^2\,5d^2$ - $5s^2\,6s\,6d$	R^2(5d, 5d; 6s, 6d)	778.0	5.0	945.3	0.823
$5s^2\,5d\,6s$ - $5s^2\,6s\,6d$	R^2(5d, 6s; 6s, 6d)	-6486.0	-45.0	-7880.4	0.823
	R^0(5d, 6s; 6d, 6s)	-618.8	-4.0	-751.9	0.823
	σ	193			

CHAPTER – 5

The fifth spectrum of Iodine: I V

5.1. Introduction:

The four-time ionized iodine atom is isoelectronic with In I. Its ground configuration is $5s^25p$ with a doublet structure. It is thus a simple one-electron spectrum. However, its internal excitation leads to $5s5p^2$, which is a three-electron system. Its further excitation leads to various configurations like 5s5pnl, $5p^3$, $5p^2nl$ etc. exhibiting complex structure involving quartet and doublet level system. The spectrum of iodine was first observed by Bloch *et al.* [1] in the wavelength region 190-1010 Å .In their line list, they gave ionization assignments of 2, 3 or 4 each of the lines above 400 Å indicating I II, I III, I IV and higher respectively. Four lines of I V have been classified by Even-Zohar and Fraenkel [2]. Kaufman *et al.* revised the earlier work of Even-Zohar and Fraenkel [2] and O'Neill *et al.* [3]. Kaufman *et al.* [4] covering the configurations $5s^25p$, $5s5p^2$, $5s^25d$, $5s^26d$, $5s^26s$, 7s, 8s and $5p^3\ ^4S_{3/2}$ classified 26 lines of I V and gave the value of ionization potential. Tauheed, Joshi and Pinigton [5] revised and extended the analysis of I V to include the new configurations $5s^26p$, $5p^3$, 5s5p5d and 5s5p6s.

This analysis is further extended in the present work and will be describe in more detail in the following sections.

5.2. The Term Structure of I V:

Ground configuration:

$5s^25p$: $^2P_{1/2}$, $^2P_{3/2}$

Excited configurations:

$5s^2np$: $^2P_{1/2}$, $^2P_{3/2}$

$5s^2ns$: $^2S_{1/2}$

$5s^2nd$: $^2D_{3/2}$, $^2D_{5/2}$

$5s^2nf$: $^2F_{5/2}$, $^2F_{7/2}$

$5s^2ng$: $^2G_{7/2}$, $^2G_{9/2}$

$5s5p^2$: $(^3P)\ ^4P_{1/2,3/2,5/2}$, $^2P_{1/2,3/2}$
$(^1D)\ ^2D_{3/2,5/2}$; $(^1S)\ ^2S_{1/2}$

$5p^3$: $(^2P)\ ^2P_{1/2,3/2}$; $(^2D)\ ^2D_{3/2,5/2}$; $(^4S)\ ^4S_{3/2}$

$5s5p5d$: $(^3P)\ ^4F_{3/2,5/2,7/2,9/2}$, $^4D_{1/2,3/2,5/2,7/2}$, $^4P_{1/2,3/2,5/2}$
$^2F_{5/2,7/2}$, $^2D_{3/2,5/2}$, $^2P_{1/2,3/2}$
$(^1P)\ ^2F_{5/2,7/2}$, $^2D_{3/2,5/2}$, $^2P_{1/2,3/2}$

$5s5p6s$: $(^3P)\ ^4P_{1/2,3/2,5/2}$, $^2P_{1/2,3/2}$; $(^1P)\ ^2P_{1/2,3/2}$

$5p^25d$: $(^3P)\ ^4F_{3/2,5/2,7/2,9/2}$, $^4D_{1/2,3/2,5/2,7/2}$, $^4P_{1/2,3/2,5/2}$
$^2F_{5/2,7/2}$, $^2D_{3/2,5/2}$, $^2P_{1/2,3/2}$
$(^1D)\ ^2G_{7/2,9/2}$, $^2F_{5/2,7/2}$, $^2D_{3/2,5/2}$, $^2P_{1/2,3/2}$, $^2S_{1/2}$
$(^1S)\ ^2D_{3/2,5/2}$

$5p^26s$: $(^3P)\ ^4P_{1/2,3/2,5/2}$, $^2P_{1/2,3/2}$
$(^1D)\ ^2D_{3/2,5/2}$; $(^1S)\ ^2S_{1/2}$

5.3. Results and discussion:

The *ab initio* calculations were performed using Cowan's computer code incorporating the configurations $5s^25p$, 6p, 7p, 8p, 4f, 5f, 6f, $5p^3$, 5s5p5d, 5s5p6s, $5p^24f$ and $5p^26p$ for odd parity matrix and $5s^25d$, 6d, 7d, 8d, 6s, 7s, 8s, 9s, 5g, 6g, 7g $5p^25d$, $5p^26s$ and 5s5p4f configurations for even parity matrix. The initial energy parameter scaling applied for E_{av} and

ζ at 100 % of the HFR values and F^k at 85 % , G^k and R^k at 75 % of the HFR values.

Thorough investigation was carried out to verify the published work. It was found that the levels reported by Tauheed *et al.* [5] were correct and are therefore, confirmed in the present work. The existing analysis has been extended considerably to include the new configurations $5s^29s$, $5s^27p$, $5s^28p$, $5s^24f$, $5s^25f$, $5s^26f$, $5s^27d$, $5s^25g$, $5s^26g$, $5p^25d$ and $5p^26s$. In the new analysis there are nine configurations which are one electron, consequently exhibiting doublet structure while the two even parity configurations, namely $5p^25d$ and $5p^26s$ are three electron system and are much more complex. Due to large number of levels from $5p^2(5d+6s)$ configurations giving transitions to $5p^3$ + 5s5p5d+ 5s5p6s configurations, quite a few lines are doubly classified. However, these lines are not primary transitions rather supporting transitions therefore, posing no doubts on the analysis. Due attention has been paid in deciding the ionization assignments particularly to those levels which are based on single transition. It should be pointed out that in the previously reported least squares fit [5] all the levels are nicely fitting. However, in that fit $5s^25f$, $5s^26f$, $5s^27f$, $5s^27p$, $5s^28p$, $5p^24f$, $5p^26p$ and 4f5s5d configuration were not included. With the inclusion of these extra configurations, we noticed strong interaction of $5s^25f$ levels with the levels of 5s5p5d configuration. This perturbation has changed the previously reported fit. Only two levels especially one J = 1/2 at 280302 cm^{-1} is showing 838 cm^{-1} deviation and the other J = 3/2 level at 281053 cm^{-1} is deviated by 610 cm^{-1}. This clearly suggested that these two levels should be interchanged. Consequently these levels have been interchanged and least square fit is again quiet reasonable. Obviously the older LS composition has changed a little bit but not significantly. The levels of $5s^2 4f$ were found to be normal while in $5s^2 5f$ and $5s^2 6f$ they were observed inverted in accordance with HF calculations. Fig. 5.1 shows the energy spread of various odd parity configurations. Three high lying configurations $5p^2 4f$, $5p^2 6p$, 4f5s5d were not studied but they were only incorporated in the configuration interaction calculations, their energy parameters were held fixed at predetermined Hartee-Fock values. These configurations lie quite high and were not populated.

The even parity configurations studied are $5s5p^2$, $5s^2 5d$, $5s^2 6d$, $5s^2 7d$, $5s^2 6s$, $5s^2 7s$, $5s^2 8s$, $5s^2 9s$, $5s^2 5g$, $5s^2 6g$, $5p^2 5d$ and $5p^2 6s$. The only configuration, which could not be studied was 5s5p4f because this configuration could be studied through the transitions to 5s5p5d. Fig. 5.2 shows that this configuration lies close to 5s5p4f consequently these transition lie in higher wavelength region, beyond our region of present investigation. The situation in even parity configuration is much better. The standard deviation of the entire fit is only 204 cm^{-1}. Due to the interaction of $5s^2 5g$ & 6g configurations with 5s5p4f configuration the $^2G_{9/2}$ levels have been found lower than $^2G_{7/2}$ as predicted in *ab initio* calculations. Normally 5g and 6g levels do not show any splitting but this interaction causes small splitting of the 5g and 6g levels. The energy spread of various even parity configurations are shown in Fig. 5.3.

One hundred and six levels have been established in this ion out of which **53** are new. **Three hundred and fifteen** lines have been classified in I V and they are given in Table 5.1. The odd parity levels along with their fitted values are given in Table 5.2 and even parity levels in Table 5.3. The energy parameter used for least squares fitted calculations for odd and even parity configurations are given in Table 5.4 and 5.5 respectively.

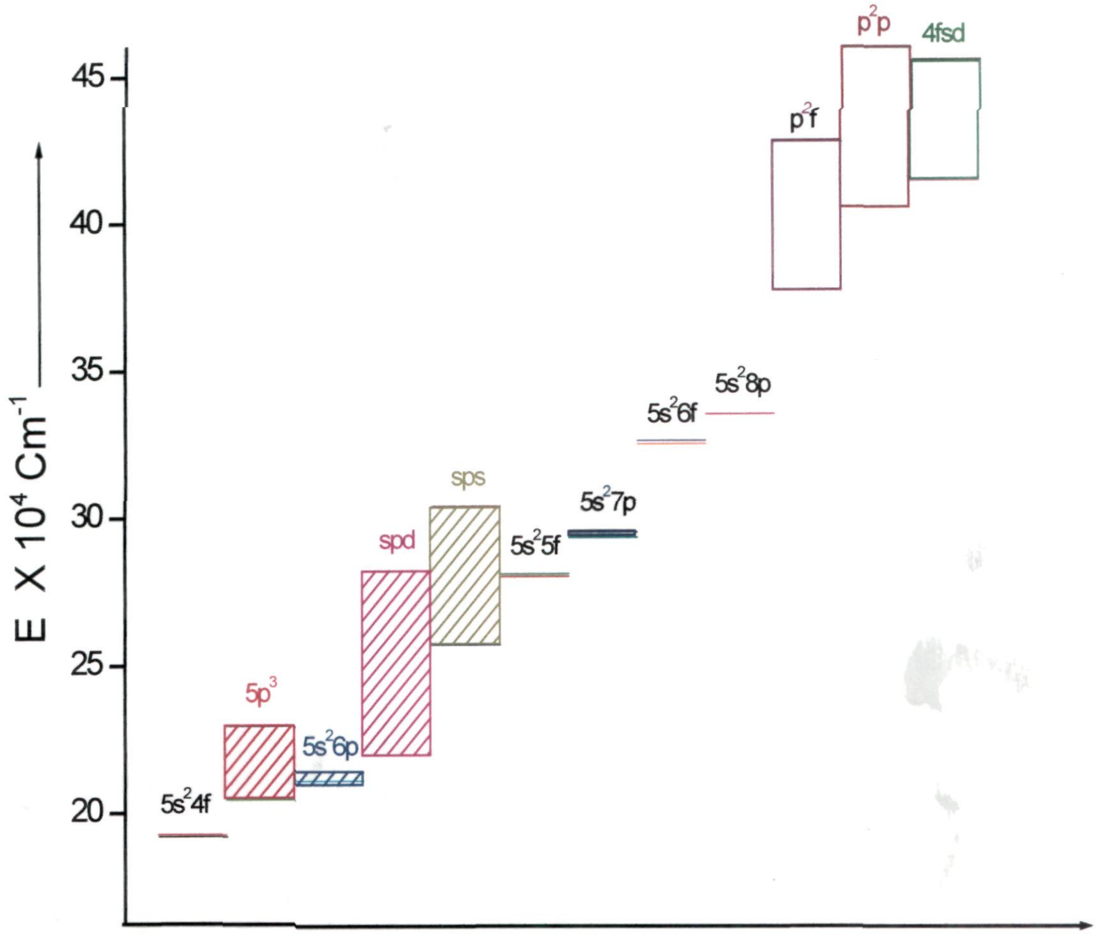


Fig. 5.1. Energy spread of various configurations in odd parity system of I V, unfilled blocks represent not studied configurations.

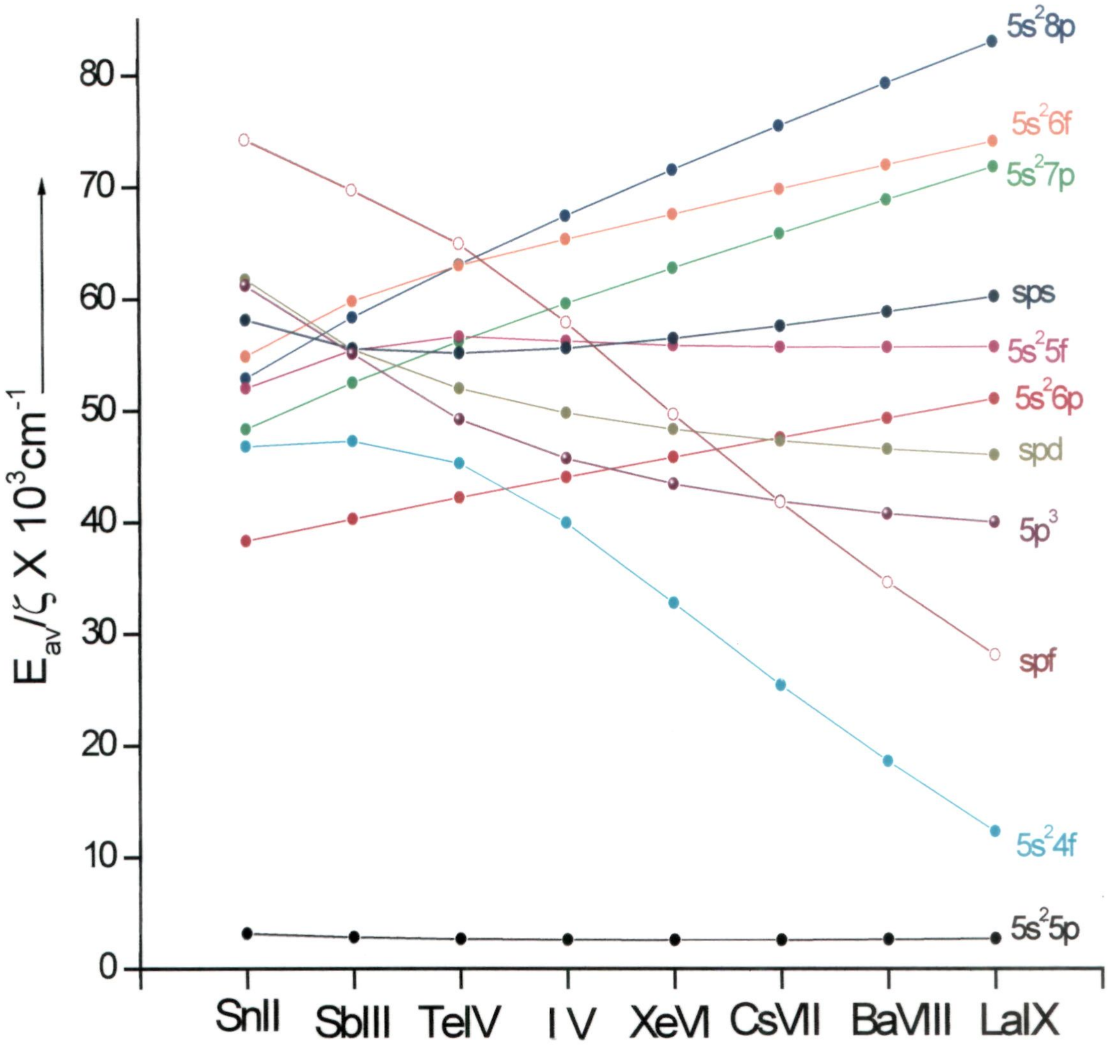


Fig. 5.2. E_{av}/ζ X 10^3cm^{-1} for SnII isoelectronic sequence where filled circles represent odd parity & hollow circle repersents even parity configuration

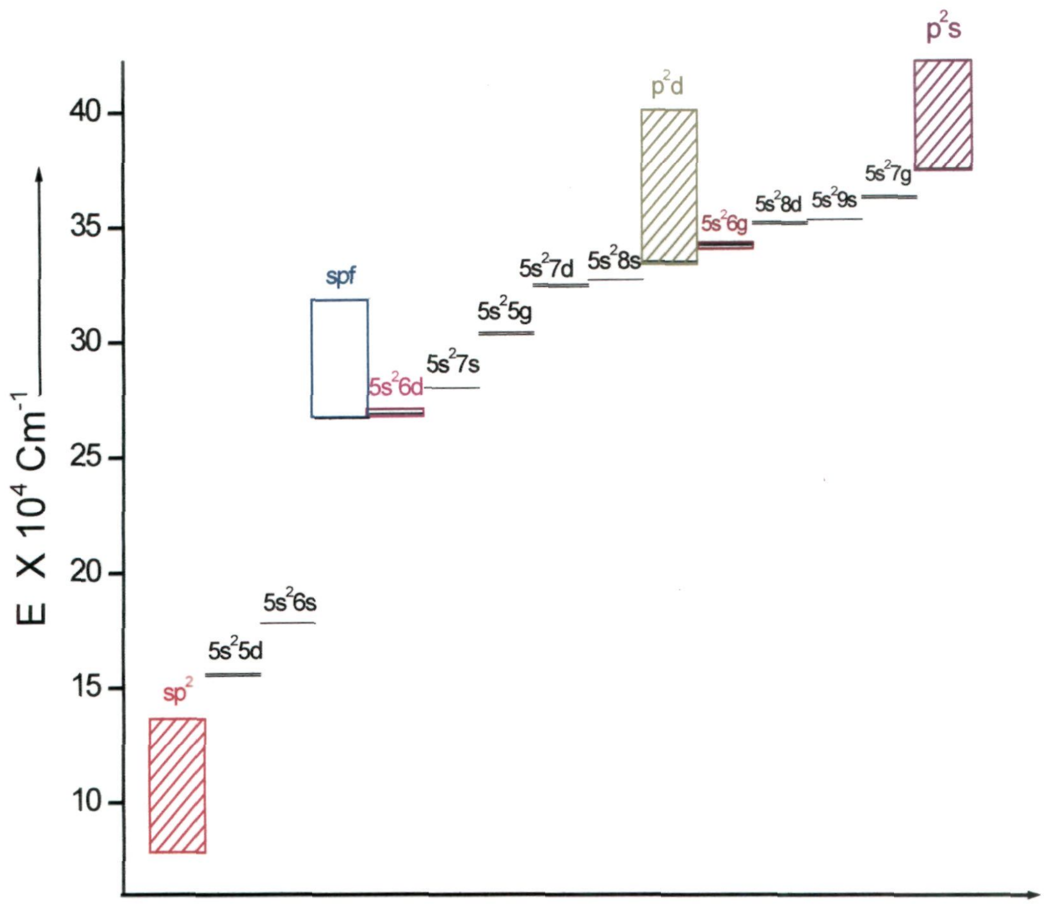


Fig. 5.3. Energy spread of various configurations in even parity system of I V, unfilled block represents not studied configuration.

5.4. Ionization Potential:

Ionization energy was calculated by Kaufman and Joshi [4] using three members of ns series (n = 6 – 8). They applied a correction to the ionization energy derived using ng series in Sn II [6] and adapted the series limit at 415510 ± 300 cm^{-1}. Our calculated series limit agrees well with the value given by Kaufman *et al.* [4]. We therefore retain the same ionization potential of I V at 415510 ± 300 cm^{-1} or 51.52 ± 0.04 eV

References:

1. L. Bloch, E. Bloch and N. Felici, "Recherches sur les specters d' étincelle de I'iode dans l'ultraviolet extreme," J. Phys. Rad. **8**, 355 (1937).
2. M. Even-Zohar and B. S. Fraenkel, "A study of EUV spectra in the fifth period," J. Phys. **B 5**, 1596 (1972).
3. J.A. O' Niell, E.H. Pinnington, K. E. Donnelly, and R.L. Brooks, " A study of the beam foil spectrum of iodine from 400 to 1300Å," Phys Scr. **20**, 60 (1979).
4. Kaufman V. Sugar J and Joshi Y.N. J. Opt. Soc. Am. **B 5**, 619(1988).
5. A Tauheed, Y.N. Joshi and E.H. Pinnington, " Analysis of the 5s25d, 5p3, 5s5p5d and 5s5p6s configurations of four-times ionized iodine: I V" J. Phys. B (UK) **31**, 393 (1988).
6. C. E. Moore, Atomic Energy Levels, Natl. Bur. Stand. (U.S.) Circ. Vol III (1958).

Table 5.1. Classified lines of I V Spectrum

Wavelength λ(Å)	Wave number ν (cm^{-1})	Int	Ch[a]	Classification[b]	diff.[c] Δ λ(Å)
310.246	322324.90	45		$5p\ ^2P_{1/2}$ - $8s\ ^2S_{1/2}$	0.001
322.475	310102.00	25		$5p\ ^2P_{3/2}$ - $8s\ ^2S_{1/2}$	0.002
363.825	274857.50	55		$5p\ ^2P_{1/2}$ - $7s\ ^2S_{1/2}$	0.000
378.177	264426.40	50		$5p\ ^2P_{1/2}$ - $6d\ ^2D_{3/2}$	0.002
380.753	262637.30	75		$5p\ ^2P_{3/2}$ - $7s\ ^2S_{1/2}$	-0.003
395.475	252860.20	45		$5p\ ^2P_{3/2}$ - $6d\ ^2D_{5/2}$	0.001
396.499	252207.40	5		$5p\ ^2P_{3/2}$ - $6d\ ^2D_{3/2}$	-0.003
471.558	212063.00	25		$sp^2(^3P)\,^4P_{5/2}$ - $sps(^1P)\,^2P_{3/2}$	0.000
508.875	196511.90	10		$sp^2(^3P)\,^4P_{1/2}$ - $sps(^3P)\,^2P_{3/2}$	0.003
510.558	195864.20	40		$sp^2(^1D)\,^2D_{3/2}$ - $sps(^1P)\,^2P_{1/2}$	0.002
510.628	195837.10	20		$sp^2(^1D)\,^2D_{3/2}$ - $sps(^1P)\,^2P_{3/2}$	0.000
514.296	194440.70	10		$sp^2(^3P)\,^4P_{3/2}$ - $spd(^1P)\,^2D_{5/2}$	0.009
514.643	194309.30	25		$5p^3\ ^4S_{3/2}$ - $p2s(^1D)\,^2D_{3/2}$	-0.004
514.940	194197.30	10		$5p^3\ ^2D_{5/2}$ - $p2s(^1D)\,^2D_{3/2}$	0.009
518.713	192784.70	55		$sp^2(^1D)\,^2D_{5/2}$ - $sps(^1P)\,^2P_{3/2}$	0.003
521.341	191813.00	5		$sp^2(^3P)\,^4P_{3/2}$ - $spd(^1P)\,^2F_{5/2}$	0.008
522.892	191244.00	15		$sp^2(^3P)\,^4P_{5/2}$ - $spd(^1P)\,^2P_{3/2}$	0.005
524.613	190616.80	10		$sp^2(^3P)\,^4P_{3/2}$ - $sps(^3P)\,^2P_{3/2}$	0.002
529.690	188789.50	10		$sp^2(^3P)\,^4P_{5/2}$ - $spd(^1P)\,^2D_{5/2}$	-0.004
534.253	187177.20	75		$sp^2(^3P)\,^4P_{3/2}$ - $sps(^3P)\,^4P_{5/2}$	0.001
538.858	185577.80	55		$sp^2(^3P)\,^4P_{5/2}$ - $spd(^1P)\,^2F_{7/2}$	-0.009
540.042	185170.80	65		$sp^2(^3P)\,^4P_{1/2}$ - $spd(^3P)\,^2P_{3/2}$	-0.003
540.654	184961.20	10		$sp^2(^3P)\,^4P_{5/2}$ - $sps(^3P)\,^2P_{3/2}$	0.002
546.046	183134.90	75		$sp^2(^3P)\,^4P_{1/2}$ - $sps(^3P)\,^4P_{3/2}$	-0.004
550.902	181520.60	75		$sp^2(^3P)\,^4P_{5/2}$ - $sps(^3P)\,^4P_{5/2}$	0.004
551.123	181447.70	18		$sp^2(^3P)\,^4P_{3/2}$ - $sps(^3P)\,^2P_{1/2}$	-0.003
554.434	180364.00	50		$sp^2(^3P)\,^4P_{1/2}$ - $sps(^3P)\,^4P_{1/2}$	-0.003
554.617	180304.60	35		$5d\ ^2D_{3/2}$ - $8p\ ^2P_{1/2}$	0.007
554.887	180216.80	30		$5d\ ^2D_{5/2}$ - $8p\ ^2P_{3/2}$	0.000
557.805	179274.00	55		$sp^2(^3P)\,^4P_{3/2}$ - $spd(^3P)\,^2P_{3/2}$	0.001

558.927	178914.10	55		$sp^2(^3P)^2P_{1/2}$ - $sps(^1P)^2P_{3/2}$	0.001
560.514	178407.70	10		$5p^3\ ^4S_{3/2}$ - $p^2s(^3P)^4P_{5/2}$	0.011
564.215	177237.50	60		$sp^2(^3P)^4P_{3/2}$ - $sps(^3P)^4P_{3/2}$	0.002
565.467	176844.90	30		$5p^3\ ^2D_{5/2}$ - $p2d(^3P)^2F_{7/2}$	0.014
565.565	176814.20	76		$5p\ ^2P_{1/2}$ - $6s\ ^2S_{1/2}$	0.002
570.293	175348.40	15		$5p^3\ ^2D_{3/2}$ - $p^2d(^3P)^2D_{5/2}$	0.013
571.367	175018.80	20		$sp^2(^1D)^2D_{3/2}$ - $spd(^1P)^2P_{3/2}$	0.003
573.171	174468.00	74		$sp^2(^3P)^4P_{3/2}$ - $sps(^3P)^4P_{1/2}$	-0.001
574.266	174135.20	45		$5p^3\ ^2D_{5/2}$ - $p^2d(^3P)^2F_{5/2}$	-0.005
575.582	173737.30	30		$5d\ ^2D_{3/2}$ - $6f\ ^2F_{5/2}$	0.004
575.972	173619.60	65		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^2P_{3/2}$	-0.003
579.504	172561.50	70	B	$sp^2(^1D)^2D_{3/2}$ - $spd(^1P)^2D_{5/2}$	0.002
580.466	172275.40	65		$sp^2(^1D)^2D_{3/2}$ - $spd(^1P)^2P_{1/2}$	-0.009
580.497	172266.30	25		$5d\ ^2D_{5/2}$ - $6f\ ^2F_{7/2}$	0.009
581.495	171970.50	70		$sp^2(^1D)^2D_{5/2}$ - $spd(^1P)^2P_{3/2}$	-0.006
582.812	171582.00	75		$sp^2(^3P)^4P_{5/2}$ - $sps(^3P)^4P_{3/2}$	0.001
583.014	171522.40	10		$sp^2(^1D)^2D_{3/2}$ - $spd(^1P)^2D_{3/2}$	-0.002
583.936	171251.60	10		$5p^3\ ^2P_{3/2}$ - $p^2s(^1D)^2D_{3/2}$	-0.003
588.470	169932.20	75		$sp^2(^1D)^2D_{3/2}$ - $spd(^1P)^2F_{5/2}$	0.006
588.788	169840.30	30		$5p^3\ ^2P_{3/2}$ - $p^2s(^1D)^2D_{5/2}$	0.000
593.664	168445.50	10		$5p^3\ ^2P_{3/2}$ - $p^2d(^1S)^2D_{3/2}$	0.005
598.569	167065.00	70		$sp^2(^3P)^4P_{1/2}$ - $spd(^3P)^2D_{3/2}$	0.000
599.233	166880.10	50		$sp^2(^1D)^2D_{5/2}$ - $spd(^1P)^2F_{5/2}$	0.010
600.061	166649.70	50		$5p^3\ ^4S_{3/2}$ - $p^2s(^3P)^4P_{1/2}$	-0.005
600.127	166631.30	60		$5p^3\ ^2P_{3/2}$ - $p^2d(^1S)^2D_{5/2}$	0.004
601.254	166319.00	30		$sp^2(^1S)^2S_{1/2}$ - $sps(^1P)^2P_{1/2}$	-0.008
601.331	166297.90	85		$sp^2(^1D)^2D_{5/2}$ - $spd(^1P)^2F_{7/2}$	-0.001
602.350	166016.40	70		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^2F_{7/2}$	0.000
602.544	165963.10	5		$sp^2(^3P)^4P_{1/2}$ - $spd(^3P)^4P_{3/2}$	0.003
603.564	165682.60	75		$sp^2(^1D)^2D_{5/2}$ - $sps(^3P)^2P_{3/2}$	0.008
604.987	165292.90	70		$sp^2(^1D)^2D_{3/2}$ - $sps(^3P)^4P_{5/2}$	0.010
605.161	165245.40	74	D	$sp^2(^1D)^2D_{3/2}$ - $spd(^3P)^2P_{1/2}$	-0.002
				$sp^2(^3P2P_{3/2}$ - $sps(^1P)^2P_{1/2}$	0.005
605.255	165219.70	65		$sp^2(^3P)^2P_{3/2}$ - $sps(^1P)^2P_{3/2}$	-0.004

606.570	164861.50	65		$sp^2(^3P)^4P_{3/2}$ - $spd(^3P)^2D_{5/2}$	0.004
607.556	164594.00	95		$5p\ ^2P_{3/2}$ - $6s\ ^2S_{1/2}$	-0.006
610.746	163734.30	70		$5p^3\ ^2P_{1/2}$ - $p^2s(^3P)^2P_{3/2}$	0.004
613.141	163094.70	25		$5p^3\ ^2D_{3/2}$ - $p^2d(^1D)^2D_{5/2}$	0.002
616.342	162247.70	4		$sp^2(^1D)^2D_{5/2}$ - $sps(^3P)^4P_{5/2}$	-0.011
620.467	161169.00	65		$sp^2(^3P)^4P_{3/2}$ - $spd(^3P)^2D_{3/2}$	0.002
621.347	160940.60	70		$sp^2(^3P)^4P_{3/2}$ - $spd(^3P)^4P_{1/2}$	0.002
622.687	160594.30	10		$5p^3\ ^4S_{3/2}$ - $p^2d(^3P)^2D_{3/2}$	-0.004
624.727	160069.90	65		$sp^2(^3P)^4P_{3/2}$ - $spd(^3P)^4P_{3/2}$	-0.005
626.709	159563.80	75		$sp^2(^1D)^2D_{3/2}$ - $sps(^3P)^2P_{1/2}$	0.003
627.833	159278.00	85	B	$sp^2(^3P)^4P_{3/2}$ - $spd(^3P)^4D_{5/2}$	-0.019
628.125	159204.00	5		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^2D_{5/2}$	0.011
629.750	158793.10	25		$5p^3\ ^2P_{1/2}$ - $p^2s(^3P)^2P_{1/2}$	-0.002
631.174	158434.90	65		$sp^2(^3P)^4P_{3/2}$ - $spd(^3P)^2F_{5/2}$	-0.013
632.616	158073.80	25		$5p^3\ ^4S_{3/2}$ - $p^2d(^1D)^2D_{3/2}$	0.001
634.745	157543.50	25		$6s\ ^2S1_{/2}$ - $8p\ ^2P_{1/2}$	-0.006
635.357	157391.90	20		$sp^2(^1D)^2D_{3/2}$ - $spd(^3P)^2P_{3/2}$	0.002
639.191	156447.70	72		$sp^2(^3P)^4P_{1/2}$ - $spd(^3P)^4D_{1/2}$	-0.003
639.810	156296.50	80	B	$sp^2(^3P)^4P_{1/2}$ - $spd(^3P)^4D_{3/2}$	-0.002
643.027	155514.50	10		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^2D_{3/2}$	-0.004
643.689	155354.60	55	D	$sp^2(^1D)^2D_{3/2}$ - $sps(^3P)^4P_{3/2}$	0.006
				$sp^2(^3P)^2P_{1/2}$ - $spd(^1P)^2P_{1/2}$	-0.018
646.828	154600.60	60		$sp^2(^3P)^2P_{1/2}$ - $spd(^1P)^2D_{3/2}$	-0.006
647.614	154413.00	65		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^4P_{3/2}$	-0.001
647.906	154343.30	10		$sp^2(^1D)^2D_{5/2}$ - $spd(^3P)^2P_{3/2}$	-0.008
649.142	154049.50	80		$5p\ ^2P_{1/2}$ - $5d\ ^2D_{3/2}$	0.001
650.960	153619.30	70		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^4D_{5/2}$	-0.008
654.546	152777.60	78		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^2F_{5/2}$	-0.008
655.361	152587.60	14		$sp^2(^1D)^2D_{3/2}$ - $sps(^3P)^4P_{1/2}$	-0.008
656.579	152304.60	55		$sp^2(^1D)^2D_{5/2}$ - $sps(^3P)^4P_{3/2}$	0.002
657.114	152180.70	80		$sp^2(^3P)^4P_{5/2}$ - $spd(^3P)^4D_{7/2}$	-0.001
657.510	152088.90	40		$5p^3\ ^2P_{3/2}$ - $p2d(^1D)^2P_{3/2}$	0.004
657.730	152038.00	53		$sp^2(^3P)^4P_{1/2}$ - $5p^3\ ^2P_{3/2}$	-0.006
658.710	151811.90	48		$sp^2(^3P)^2P_{1/2}$ - $sps(^3P)^2P_{3/2}$	0.005
664.223	150551.90	15		$sp^2(^3P)^4P_{3/2}$ - $spd(^3P)^4D_{1/2}$	-0.002

664.886	150401.80	76	B	$sp^2(^3P)^4P_{3/2} - spd(^3P)^4D_{3/2}$	-0.005
666.036	150142.00	20		$5p^3\ ^2P_{3/2} - p^2s(^3P)^4P_{3/2}$	-0.008
667.006	149923.70	10		$5p^3\ ^2P_{1/2} - p^2d(^1D)^2P_{1/2}$	0.006
668.707	149542.30	70		$5p^3\ ^2D_{3/2} - p^2d(^3P)^2P_{1/2}$	0.001
668.977	149481.90	80		$sp^2(^3P)^4P_{3/2} - spd(^3P)^4P_{5/2}$	-0.002
673.871	148396.30	15		$5p^3\ ^4S_{3/2} - p^2d(^3P)^4P_{3/2}$	0.013
674.198	148324.30	75		$sp^2(^3P)^2P_{1/2} - spd(^3P)^2P_{1/2}$	-0.009
677.006	147709.20	50		$5p^3\ ^2P_{1/2} - p^2s(^3P)^4P_{1/2}$	-0.010
677.164	147674.70	55		$5p^3\ ^2P_{3/2} - p^2d(^1D)^2S_{1/2}$	-0.004
678.747	147330.40	25		$spd(^3P)^2F_{5/2} - p^2s(^3P)^2P_{3/2}$	-0.004
681.481	146739.30	80		$sp^2(^1D)^2D_{5/2} - spd(^3P)^2F_{7/2}$	0.000
684.264	146142.40	20		$sp^2(^3P)^4P_{3/2} - 5p^3\ ^2P_{3/2}$	-0.005
685.821	145810.70	65		$5p^3\ ^2P_{3/2} - p^2d(^1D)^2P_{1/2}$	-0.005
687.066	145546.40	50		$5p^3\ ^4S_{3/2} - p^2d(^3P)^4P_{5/2}$	0.009
687.418	145472.00	70		$sp^2(^1S)^2S_{1/2} - spd(^1P)^2P_{3/2}$	-0.003
690.870	144745.00	15		$sp^2(^3P)^4P_{5/2} - spd(^3P)^4D_{3/2}$	-0.001
692.526	144399.00	65		$sp^2(^3P)^2P_{3/2} - spd(^1P)^2P_{3/2}$	0.011
695.289	143825.00	65		$sp^2(^3P)^4P_{5/2} - spd(^3P)^4P_{5/2}$	0.004
698.132	143239.40	85		$5p\ ^2P^{3/2} - 5d\ ^2D_{5/2}$	0.001
698.921	143077.60	28		$sp^2(^3P)^4P_{1/2} - spd(^3P)^4F_{3/2}$	0.004
699.396	142980.50	48		$sp^2(^1D)^2D_{3/2} - spd(^3P)^2D_{5/2}$	0.001
700.659	142722.80	60		$sp^2(^1S)^2S_{1/2} - spd(^1P)^2P_{1/2}$	0.007
702.001	142450.00	15		$5p^3\ ^2D_{3/2} - p^2d(^3P)^4D_{3/2}$	-0.016
704.364	141972.10	15		$sp^2(^1S)^2S_{1/2} - spd(^1P)^2D_{3/2}$	0.006
704.502	141944.20	76		$sp^2(^3P)^2P_{3/2} - spd(^1P)^2D_{5/2}$	-0.003
705.083	141827.20	75		$5p\ ^2P_{3/2} - 5d\ ^2D_{3/2}$	0.002
705.952	141652.70	68		$sp^2(^3P)^2P_{3/2} - spd(^1P)^2P_{1/2}$	0.008
706.174	141608.20	15		$spd(^3P)^2F_{5/2} - p^2d(^3P)^2F_{7/2}$	0.005
709.698	140905.00	25	B	$sp^2(^3P)^2P_{3/2} - spd(^1P)^2D_{3/2}$	-0.009
711.893	140470.60	75		$sp^2(^3P)^2P_{1/2} - spd(^3P)^2P_{3/2}$	-0.003
712.361	140378.30	70		$5d\ ^2D_{5/2} - 7p\ ^2P_{3/2}$	0.007
714.643	139930.10	80		$sp^2(^1D)^2D_{5/2} - spd(^3P)^2D_{5/2}$	-0.002
716.041	139656.90	85		$5d\ ^2D_{3/2} - 7p\ ^2P_{1/2}$	-0.008
716.185	139628.70	70		$sp^2(^3P)^4P_{3/2} - spd(^3P)^4F_{5/2}$	-0.005

717.370	139398.10	85	5p $^2P_{1/2}$	- sp2 (^{3}P) $^2P_{3/2}$	0.005
717.802	139314.20	78	sp^2 (^{3}P) $^2P_{3/2}$	- spd (^{1}P) $^2F_{5/2}$	0.007
717.938	139287.70	78	sp^2 (^{1}D) $^2D_{3/2}$	- spd (^{3}P) $^2D_{3/2}$	- 0.001
717.995	139276.70	30	^{4}f $^2F_{5/2}$	- 6g $^2G_{7/2}$	0.000
719.646	138957.20	30	^{4}f $^2F_{7/2}$	- 6g $^2G_{9/2}$	0.000
722.362	138434.80	74	sp2 (^{3}P) $^2P_{1/2}$	- sps (^{3}P) $^4P_{3/2}$	-0.006
722.918	138328.30	85	5p $^2P_{1/2}$	- sp2 (^{1}S) $^2S_{1/2}$	0.004
723.663	138185.80	76	sp^2 (^{1}D) $^2D_{3/2}$	- spd (^{3}P) $^4P_{3/2}$	0.004
724.027	138116.40	20	sp^2 (^{3}P) $^2P_{3/2}$	- sps (^{3}P) $^2P_{3/2}$	0.005
724.379	138049.30	10	sp^d (^{3}P) $^4D_{5/2}$	- p^{2}d (^{3}P) $^2F_{5/2}$	0.013
725.932	137754.00	75	sp^2 (^{3}P) $^4P_{5/2}$	- spd (^{3}P) $^4F_{7/2}$	0.003
726.080	137725.80	30	5p^3 $^4S_{3/2}$	- p^{2}d (^{3}P) $^4D_{5/2}$	0.004
727.827	137395.30	70	sp^2 (^{1}D) $^2D_{3/2}$	- spd (^{3}P) $^4D_{5/2}$	-0.022
728.554	137258.20	15	spd (^{3}P) $^4P_{3/2}$	- p^{2}d (^{3}P) $^2F_{5/2}$	-0.009
728.963	137181.20	63	sp^2 (^{3}P) $^4P_{3/2}$	- spd (^{3}P) $^4F_{3/2}$	0.010
730.826	136831.40	25	5p^3 $^2D_{5/2}$	- p^{2}d (^{3}P) $^4D_{3/2}$	0.002
732.337	136549.20	75	sp^2 (^{1}D) $^2D_{3/2}$	- spd (^{3}P) $^2F_{5/2}$	0.002
734.012	136237.50	70	sp^2 (^{1}D) $^2D_{5/2}$	- spd (^{3}P) $^2D_{3/2}$	-0.006
736.944	135695.50	75	sp^2 (^{1}S) $^2S_{1/2}$	- spd (^{3}P) $^2P_{1/2}$	0.005
740.005	135134.20	68	sp^2 (^{1}D) $^2D_{5/2}$	- spd (^{3}P) $^4P_{3/2}$	0.008
742.519	134676.60	50	sp^2 (^{3}P) $^2P_{3/2}$	- sps (^{3}P) $^4P_{5/2}$	0.004
742.799	134625.90	5	sp^2 (^{3}P) $^2P_{3/2}$	- spd (^{3}P) $^2P_{1/2}$	0.003
744.372	134341.50	27	sp^2 (^{1}D) $^2D_{5/2}$	- spd (^{3}P) $^4D_{5/2}$	-0.007
745.495	134139.00	75	6p $^2P_{3/2}$	- 9s $^2S_{1/2}$	0.000
746.426	133971.70	60	sp^2 (^{3}P) $^4P_{5/2}$	- spd (^{3}P) $^4F_{5/2}$	0.002
749.065	133499.70	40	spd (^{3}P) $^2P_{3/2}$	- p^{2}d (^{1}S) $^2D_{5/2}$	-0.002
752.424	132903.70	65	sp^2 (^{1}D) $^2D_{5/2}$	- spd (^{3}P) $^4D_{7/2}$	-0.002
753.762	132667.90	15	5p^3 $^4S_{3/2}$	- p^{2}d (^{3}P) $^4D_{1/2}$	-0.004
758.770	131792.20	15	5p^3 $^4S_{3/2}$	- p^{2}d (^{1}D) $^2F_{5/2}$	0.011
763.335	131004.00	35	5p^3 $^2D_{5/2}$	- p^{2}d (^{3}P) $^2P_{3/2}$	-0.010
769.117	130019.30	8	sp^2 (^{1}S) $^2S_{1/2}$	- sps (^{3}P) $^2P_{1/2}$	-0.018
770.705	129751.30	35	5d $^2D_{3/2}$	- spd (^{1}P) $^2P_{3/2}$	-0.004
775.309	128980.80	70	sp^2 (^{3}P) $^4P_{1/2}$	- 5p^3 $^4S_{3/2}$	-0.006
775.535	128943.30	48	sp^2 (^{3}P) $^2P_{3/2}$	- sps (^{3}P) $^2P_{1/2}$	0.017
775.858	128889.60	50	5d $^2D_{3/2}$	- 5f $^2F_{5/2}$	0.000

777.189	128668.80	15		$sp^2(^1D)^2D_{3/2}$ - $spd(^3P)^4D_{1/2}$	0.004
778.102	128517.80	60		$sp^2(^1D)^2D_{3/2}$ - $spd(^3P)^4D_{3/2}$	0.005
779.182	128339.80	65		$5d\ ^2D_{5/2}$ - $spd(^1P)^2P_{3/2}$	-0.008
780.311	128154.10	40		$sp^2(^3P)^4P_{3/2}$ - $6p\ ^2P_{3/2}$	0.005
782.205	127843.80	66		$sp^2(^1S)^2S_{1/2}$ - $spd(^3P)^2P_{3/2}$	0.002
782.280	127831.50	60		$6s\ ^2S_{1/2}$ - $sps(^1P)^2P_{1/2}$	-0.003
782.459	127802.30	75	B	$6s\ ^2S_{1/2}$ - $sps(^1P)^2P_{3/2}$	0.003
783.705	127599.00	28		$sp^2(^1D)^2D_{3/2}$ - $spd(^3P)^4P_{5/2}$	0.003
785.595	127292.00	60		$5d\ ^2D_{3/2}$ - $spd(^1P)^2D_{5/2}$	0.005
786.312	127176.00	85		$5p\ ^2P_{3/2}$ - $sp^2(^3P)^2P_{3/2}$	0.005
787.383	127003.00	67		$5d\ ^2D_{3/2}$ - $spd(^1P)^2P_{1/2}$	0.003
787.685	126954.30	90		$5d\ ^2D_{5/2}$ - $5f\ ^2F_{7/2}$	0.000
788.815	126772.50	70		$sp^2(^3P)^2P_{3/2}$ - $spd(^3P)^2P_{3/2}$	0.010
791.450	126350.40	10		$sps(^3P)^4P_{1/2}$ - $p^2s(^3P)^2P_{1/2}$	0.002
792.067	126251.90	66		$5d\ ^2D_{3/2}$ - $spd(^1P)^2D_{3/2}$	0.004
792.983	126106.10	85		$5p\ ^2P_{3/2}$ - $sp^2(^1S)^2S_{1/2}$	0.004
794.100	125928.80	30		$5p^3\ ^2D_{5/2}$ - $p^2d(^3P)^4F_{5/2}$	-0.010
794.407	125880.00	67		$5d\ ^2D_{5/2}$ - $spd(^1P)^2D_{5/2}$	0.004
795.522	125703.60	85		$5p\ ^2P_{1/2}$ - $sp^2(^3P)^2P_{1/2}$	-0.003
795.844	125652.70	10		$spd(^3P)^2F_{7/2}$ - $p^2d(^3P)^2F_{5/2}$	0.000
797.025	125466.60	50		$sp^2(^1D)^2D_{5/2}$ - $spd(^3P)^4D_{3/2}$	0.007
798.431	125245.70	35		$spd(^3P)^2F_{5/2}$ - $p^2d(^3P)^2D_{3/2}$	0.003
799.403	125093.40	5		$5p^3\ ^2P_{1/2}$ - $p^2d(^3P)^2P_{1/2}$	0.000
801.676	124738.70	63		$sp^2(^3P)^2P_{3/2}$ - $sps(^3P)^4P_{3/2}$	-0.006
802.150	124665.00	72		$5d\ ^2D_{3/2}$ - $spd(^1P)^2F_{5/2}$	-0.001
802.908	124547.20	64		$sp^2(^1D)^2D_{5/2}$ - $spd(^3P)^4P_{5/2}$	0.009
804.082	124365.40	15		$4f\ ^2F_{7/2}$ - $7d\ ^2D_{5/2}$	0.021
804.413	124314.30	10		$sps(^3P)^2P_{1/2}$ - $p^2s(^3P)^2P_{3/2}$	0.001
804.768	124259.40	30	D	$sp^2(^1D)^2D_{3/2}$ - $5p^3\ ^2P_{3/2}$	-0.001
				$sps(^3P)^4P_{3/2}$ - $p^2s(^3P)^4P_{5/2}$	-0.011
806.571	123981.70	35		$4f\ ^2F_{5/2}$ - $7d\ ^2D_{3/2}$	0.002
809.911	123470.40	70	D	$sp^2(^3P)^4P_{1/2}$ - $5p^3\ ^2D_{3/2}$	0.009
				$5d\ ^2D_{3/2}$ - $sps(^3P)^2P_{3/2}$	-0.025
811.320	123255.90	16		$5d\ ^2D_{5/2}$ - $spd(^1P)^2F_{5/2}$	-0.022

811.765	123188.40	50	$sp^2(^3P)^4P_{3/2}$ - $5p^3\ ^2D_{5/2}$	0.020
812.447	123084.90	72	$sp^2(^3P)^4P_{3/2}$ - $5p^3\ ^4S_{3/2}$	-0.003
815.206	122668.40	75	$5d\ ^2D_{5/2}$ - $spd(^1P)^2F_{7/2}$	-0.007
816.334	122498.90	85	$sp^2(^3P)^4P_{5/2}$ - $6p\ ^2P_{3/2}$	0.002
817.227	122365.00	74	$sp^2(^3P)^2P_{1/2}$ - $spd(^3P)^2D_{3/2}$	0.000
817.913	122262.40	5	$spd(^3P)^4D_{7/2}$ - $p^2d(^1D)^2G_{9/2}$	0.011
818.074	122238.40	25	$spd(^3P)^2F_{5/2}$ - $p^2d(^1D)^2D_{5/2}$	0.012
818.424	122186.10	45	$5p^3\ ^2D_{5/2}$ - $p^2d(^3P)^4F_{3/2}$	-0.007
818.559	122165.90	10	$spd(^3P)^4D_{3/2}$ - $p^2d(^3P)^4P_{1/2}$	-0.006
819.316	122053.10	55	$5d\ ^2D_{5/2}$ - $sps(^3P)^2P_{3/2}$	0.009
819.897	121966.50	75	$sp^2(^3P)^2P_{3/2}$ - $sps(^3P)^4P_{1/2}$	0.005
820.924	121813.90	15	$sps(^3P)^4P_{1/2}$ - $p^2s(^3P)^4P_{3/2}$	-0.001
824.643	121264.60	5	$sp^2(^3P)^2P_{1/2}$ - $spd(^3P)^4P_{3/2}$	-0.004
825.033	121207.30	75	$sp^2(^1D)^2D_{5/2}$ - $5p^3\ ^2P_{3/2}$	0.007
825.185	121184.90	20	$spd(^1P)^2D_{3/2}$ - $p^2d(^1S)^2D_{3/2}$	-0.002
825.833	121089.90	10	$spd(^3P)^4P_{3/2}$ - $p^2d(^1D)^2D_{3/2}$	0.000
825.889	121081.70	30	$spd(^3P)^4D_{3/2}$ - $p^2d(^3P)^4P_{3/2}$	0.008
826.912	120931.90	30	$spd(^3P)^4D_{1/2}$ - $p^2d(^3P)^4P_{3/2}$	0.001
830.607	120393.90	25	$spd(^3P)^4F_{5/2}$ - $p^2d(^3P)^4D_{3/2}$	0.010
832.335	120144.00	70	$sp^2(^1D)^2D_{3/2}$ - $5p^3\ ^2P_{1/2}$	-0.002
835.291	119718.80	90	$spd(^3P)^4P_{5/2}$ - $p^2d(^3P)^4D_{7/2}$	0.012
836.042	119611.20	40	$spd(^3P)^2F_{5/2}$ - $p^2d(^1D)^2G_{7/2}$	-0.017
836.792	119504.00	10	$spd(^3P)^2D_{3/2}$ - $p^2d(^1D)^2D_{5/2}$	-0.012
839.260	119152.60	35	$spd(^3P)^4P_{5/2}$ - $p^2d(^3P)^4P_{5/2}$	-0.010
840.037	119042.40	10	$sps(^3P)^4P_{3/2}$ - $p^2s(^3P)^4P_{3/2}$	0.007
840.139	119027.90	40	$6s\ ^2S_{1/2}$ - $7p\ ^2P_{3/2}$	-0.006
850.502	117577.60	70	$sp^2(^3P)^4P_{3/2}$ - $5p^3\ ^2D_{3/2}$	-0.009
850.787	117538.20	70	$sp^2(^3P)^4P_{5/2}$ - $5p^3\ ^2D_{5/2}$	-0.019
851.574	117429.60	65	$sp^2(^3P)^4P_{5/2}$ - $5p^3\ ^4S_{3/2}$	-0.007
855.507	116889.70	45	$6s\ ^2S_{1/2}$ - $7p\ ^2P_{1/2}$	0.005
857.337	116640.30	20	$sps(^1P)^2P_{3/2}$ - $p^2s(^1S)^2S_{1/2}$	0.003
857.538	116612.90	10	$sps(^1P)^2P_{1/2}$ - $p^2s(^1S)^2S_{1/2}$	-0.002
867.283	115302.60	15	$sp^2(^1D)^2D_{3/2}$ - $spd(^3P)^4F_{3/2}$	-0.012
867.667	115251.60	30	$spd(^3P)^4F_{5/2}$ - $p^2d(^1D)^2F_{5/2}$	-0.007
871.889	114693.50	40	$sp^2(^1D)^2D_{5/2}$ - $spd(^3P)^4F_{5/2}$	0.010

873.057	114540.10	30	$spd(^3P)^2P_{3/2}$ - $p^2d(^1D)^2S_{1/2}$	0.003
874.758	114317.30	15	$sps(^3P)^4P_{5/2}$ - $p^2s(^3P)^4P_{5/2}$	0.006
879.857	113654.80	35	$spd(^3P)^2P_{3/2}$ - $p^2d(^3P)^2D_{5/2}$	-0.005
881.205	113481.00	85	$5p\ ^2P_{3/2}$ - $sp^2(^3P)^2P_{1/2}$	-0.001
884.535	113053.70	25	$spd(^3P)^2F_{5/2}$ - $p^2d(^3P)^4P_{3/2}$	-0.014
888.920	112496.10	25	$spd(^3P)^4P_{3/2}$ - $p^2d(^3P)^4P_{1/2}$	0.008
889.973	112363.00	40	$sp^2(^3P)^2P_{3/2}$ - $spd(^3P)^2D_{5/2}$	-0.006
890.872	112249.60	10	$sp^2(^1D)^2D_{5/2}$ - $spd(^3P)^4F_{3/2}$	0.003
893.483	111921.50	80	$sp^2(^3P)^4P_{5/2}$ - $5p^3\ ^2D_{3/2}$	-0.007
894.882	111746.60	5	$sp^2(^3P)^2P_{1/2}$ - $spd(^3P)^4D_{1/2}$	0.002
895.858	111624.80	40	$spd(^3P)^4P_{1/2}$ - $p^2d(^3P)^4P_{1/2}$	-0.001
897.927	111367.60	10	$spd(^3P)^4D_{7/2}$ - $p^2d(^3P)^4D_{7/2}$	-0.015
900.019	111108.80	10	$6p\ ^2P_{1/2}$ - $8s\ ^2S_{1/2}$	0.005
902.560	110795.90	35	$spd(^3P)^4D_{7/2}$ - $p^2d(^3P)^4P_{5/2}$	0.004
905.104	110484.60	30	$spd(^3P)^4F_{7/2}$ - $p^2d(^3P)^4F_{7/2}$	0.000
905.329	110457.10	35	$spd(^3P)^2P_{3/2}$ - $p^2s(^3P)^4P_{1/2}$	0.009
911.245	109740.00	70	$sp2(^1S)^2S_{1/2}$ - $spd(^3P)^2D_{3/2}$	-0.008
913.327	109489.80	10	$spd(3P)^4F_{5/2}$ - $p^2d(^3P)^4F_{5/2}$	0.009
919.280	108780.80	90	$5p\ ^2P_{1/2}$ - $sp^2(^1D)^2D_{3/2}$	-0.001
920.217	108670.00	60	$sp^2(^3P)^2P_{3/2}$ - $spd(^3P)^2D_{3/2}$	-0.008
922.233	108432.50	35	$spd(^3P)^4P_{5/2}$ - $p^2d(^3P)^4D_{7/2}$	0.001
924.273	108193.10	15	$spd(^3P)^4F_{3/2}$ - $p^2d(^3P)^4F_{3/2}$	0.003
925.485	108051.50	15	$5p^3\ ^2P_{3/2}$ - $p^2d(^3P)^2P_{3/2}$	0.008
929.638	107568.70	50	$sp^2(^3P)^2P_{3/2}$ - $spd(^3P)^4P_{3/2}$	-0.004
931.646	107336.90	60	$sp^2(^3P)^2P_{1/2}$ - $5p^3\ ^2P_{3/2}$	-0.001
932.200	107273.10	25	$6p\ ^2P_{3/2}$ - $8s\ ^2S_{1/2}$	-0.004
938.955	106501.40	20	$6p\ ^2P_{1/2}$ - $7d\ ^2D_{3/2}$	-0.001
944.001	105932.10	35	$sp^2(^3P)^2P_{3/2}$ - $spd(^3P)^2F_{5/2}$	-0.008
946.992	105597.50	30	$spd(^1P)^2D_{5/2}$ - $p^2d(^3P)^2F_{7/2}$	-0.007
957.732	104413.30	35	$spd(^3P)^4P_{5/2}$ - $p^2d(^3P)^4F_{7/2}$	0.001
958.411	104339.40	20	$spd(^3P)^2D_{5/2}$ - $p^2d(^3P)^4D_{7/2}$	0.000
967.478	103361.50	40	$6p\ ^2P_{3/2}$ - $7d\ ^2D_{5/2}$	-0.014
968.778	103222.80	70	$sp^2(^3P)^2P_{1/2}$ - $5p^3\ ^2P_{1/2}$	-0.015
973.256	102747.90	85	$4f\ ^2F_{5/2}$ - $5g\ ^2G_{7/2}$	0.000

976.218	102436.10	80	4f $^2F_{7/2}$ - 5g $^2G_{9/2}$	0.000
986.880	101329.40	20	spd(^{1}P)$^2P_{3/2}$ - p^{2}d(^{1}D)$^2P_{3/2}$	-0.001
987.069	101310.00	44	sp^2(^{1}D)$^2D_{3/2}$ - 5p^3 $^2D_{5/2}$	-0.005
988.120	101202.30	48	sp^2(^{1}D)$^2D_{3/2}$ - 5p^3 $^4S_{3/2}$	0.002
989.441	101067.20	20	spd(^{3}P)$^4D_{7/2}$ - p^{2}d(^{3}P)$^4F_{9/2}$	0.019
1003.597	99641.60	25	spd(^{3}P)$^2D_{3/2}$ - p^{2}d(^{3}P)$^4D_{5/2}$	-0.001
1003.925	99609.00	85	5p $^2P_{3/2}$ - sp^2(^{1}D)$^2D_{5/2}$	0.004
1017.715	98259.30	80	sp^2(1D)$^2D_{5/2}$ - 5p^3 $^2D_{5/2}$	-0.009
1018.840	98150.80	65	sp^2(1D)$^2D_{5/2}$ - 5p^3 $^4S_{3/2}$	0.007
1021.442	97900.80	15	sp^2(^{3}P)$^2P_{3/2}$ - spd(^{3}P)$^4D_{3/2}$	-0.005
1025.332	97529.40	20	spd(^{3}P)$^2F_{7/2}$ - p2d(^{3}P)$^4D_{7/2}$	0.004
1031.127	96981.30	5	sp^2(^{3}P)$^2P_{3/2}$ - spd(^{3}P)$^4P_{5/2}$	-0.002
1035.647	96558.00	1	5p $^2P_{3/2}$ - sp2(^{1}D)$^2D_{3/2}$	0.004
1038.426	96299.60	25	5d $^2D_{5/2}$ - spd(^{3}P)$^2D_{5/2}$	-0.003
1044.998	95694.00	75	sp^2(^{1}D)$^2D_{3/2}$ - 5p^3 $^2D_{3/2}$	0.005
1054.576	94824.80	15	spd(^{3}P)$^4D_{1/2}$ - p^{2}d(^{3}P)$^4F_{3/2}$	0.003
1054.739	94810.20	35	spd(^{3}P)$^4P_{1/2}$ - p^{2}d(^{3}P)$^4D_{1/2}$	0.003
1055.847	94710.70	10	sp^2(^{1}S)$^2S_{1/2}$ - 5p^3 $^2P_{3/2}$	0.002
1067.907	93641.10	68	sp^2(^{3}P)$^2P_{3/2}$ - 5p^3 $^2P_{3/2}$	-0.003
1079.390	92644.90	62	sp^2(^{1}D)$^2D_{5/2}$ - 5p^3 $^2D_{3/2}$	-0.017
1079.846	92605.80	10	5d $^2D_{5/2}$ - spd(^{3}P)$^2D_{3/2}$	0.004
1085.543	92119.80	30	5d $^2D_{3/2}$ - spd(^{3}P)$^4D_{5/2}$	0.027
1103.819	90594.60	50	sp^2(1S)$^2S_{1/2}$ - 5p^3 $^2P_{1/2}$	0.008
1117.003	89525.30	15	sp^2(3P)$^2P_{3/2}$ - 5p^3 $^2P_{1/2}$	0.000
1120.172	89272.00	40	5d $^2D_{5/2}$ - spd(^{3}P)$^4D_{7/2}$	0.013
1125.237	88870.20	20	spd(^{1}P)$^2F_{7/2}$ - p^{2}d(^{1}D)$^2G_{9/2}$	-0.005
1146.339	87234.20	30	spd(^{3}P)$^2F_{7/2}$ - p^{2}d(^{3}P)$^4F_{9/2}$	-0.014
1150.760	86899.10	55	5p $^2P_{1/2}$ - sp^2(^{3}P)$^4P_{3/2}$	-0.005
1159.765	86224.40	20	spd(^{1}P)$^2F_{5/2}$ - p^{2}d(^{1}D)$^2G_{7/2}$	-0.001
1186.530	84279.40	25	sp2(^{3}P)$^2P_{1/2}$ - 5p^3 $^4S_{3/2}$	0.008
1196.237	83595.50	8	spd(^{1}P)$^2D_{5/2}$ - p^{2}d(^{1}D)$^2G_{7/2}$	0.011
1214.612	82330.80	20	5d $^2D_{3/2}$ - spd(^{3}P)$^4P_{5/2}$	-0.006
1234.516	81003.40	90	5p $^2P_{1/2}$ - sp^2(^{3}P)$^4P_{1/2}$	-0.002
1244.818	80333.00	77	5p $^2P_{3/2}$ - sp^2(^{3}P)$^4P_{5/2}$	-0.012
1269.496	78771.40	55	sp^2(^{3}P)$^2P_{1/2}$ - 5p^3 $^2D_{3/2}$	0.008

1336.055	74847.20	15	5d $^2D_{5/2}$	- spd(^{3}P)$^4F_{7/2}$	-0.003
1339.117	74676.10	75	5p $^2P_{3/2}$	- sp^2(^{3}P)$^4P_{3/2}$	0.006
1401.616	71346.20	45	4f $^2F_{5/2}$	- 6d $^2D_{5/2}$	0.013
1407.689	71038.40	77	4f $^2F_{7/2}$	- 6d $^2D_{5/2}$	-0.007
1414.577	70692.50	77	4f $^2F_{5/2}$	- 6d $^2D_{3/2}$	-0.013
1453.894	68780.80	5	5p $^2P_{3/2}$	- sp^2(^{3}P)$^4P_{1/2}$	0.003
1571.329	63640.40	72	6p $^2P_{1/2}$	- 7s $^2S_{1/2}$	0.004
1578.275	63360.30	5	6d $^2D_{3/2}$	- 6f $^2F_{5/2}$	-0.001
1596.220	62648.00	65	6d $^2D_{5/2}$	- 6f $^2F_{7/2}$	-0.001
1639.231	61004.20	65	5d $^2D_{3/2}$	- 6p $^2P_{3/2}$	-0.009
1672.137	59803.70	74	6p $^2P_{3/2}$	- 7s $^2S_{1/2}$	0.000
1678.080	59591.90	75	5d $^2D_{5/2}$	- 6p $^2P_{3/2}$	-0.006
1749.261	57167.00	70	5d $^2D_{3/2}$	- 6p $^2P_{1/2}$	0.000

a: Character of the line B for blended line , D for doubly classified line.

b: 5p, 6p, 7p and 8p stand for $5s^25p$, $5s^26p$, $5s^27p$ and $5s^28p$; 6s, 7s, 8s and 9s stand for $5s^26s$, $5s^27s$, $5s^28s$ and $5s^29s$; 6d, 7d, 4f, 5f, 6f stand for $5s^26d$, $5s^27d$, $5s^24f$, $5s^25f$, $5s^26f$; spd and sps satand for 5s5p5d and 5s5p6s.

c: diff. ($\Delta\lambda$) = observed (λ) – calculated (λ) from levels from Table 5.2& 5.3.

Table 5.2. Observed and fitted energy levels (in cm^{-1}) for odd parity configurations of I V spectrum

J	E(obs)	E(LSF)	diff.	LS-composition.
1/2	0.0	-4.0	4.0	98% 5s^2 5p ^{2}P
	211216.8	211218.0	-1.2	97% 5s^2 6p ^{2}P
	228924.4	229019.0	-94.6	81% 5p^3 ^{2}P + 13% 5s 5p 5d (^{3}P)^{2}P
	237450.2	237525.0	-74.8	89% 5s 5p 5d (^{3}P)^{4}D + 7% 5s 5p 5d (^{3}P)^{4}P
	247839.8	247509.0	330.8	91% 5s 5p 5d (^{3}P)^{4}P + 7% 5s 5p 5d (^{3}P)^{4}D
	261366.4	261387.0	-20.6	92% 5s 5p 6s (^{3}P)^{4}P + 6% 5s 5p 6s (^{3}P)^{2}P
	268345.3	268162.0	183.3	72% 5s 5p 6s (^{3}P)^{2}P + 16% 5s 5p 5d (^{3}P)^{2}P
				+ 6% 5s 5p 6s (^{3}P)^{4}P
	274025.5	273949.0	76.5	67% 5s 5p 5d (^{3}P)^{2}P + 19% 5s 5p 6s (^{3}P)^{2}P
				+ 9% 5p^3 ^{2}P
	281053.3	281441.0	-387.7	89% 5s 5p 5d (^{1}P)^{2}P + 5% 5p^3 ^{2}P
	293705.1	293634.0	71.1	86% 5s^2 7p ^{2}P + 13% 5s 5p 6s (^{1}P)^{2}P
	304645.7	304469.0	176.7	82% 5s 5p 6s (^{1}P)^{2}P + 13% 5s2 7p ^{2}P
	334356.7	334513.0	-156.3	99% 5s^2 8p ^{2}P
	-	391899.0	-	88% 4f 5p^2 (^{3}P)^{4}D + 10% 4f 5p^2 (^{1}D)^{2}P
	-	405919.0	-	58% 4f 5p^2 (^{1}D)^{2}P + 16% 4f 5s 5d (^{3}F)^{2}P
				+ 11% 4f 5p^2 (^{3}P)^{4}D + 7% 4f 5s 5d (^{1}F)^{2}P
	-	406923.0	-	49% 5p^2 6p (^{3}P)^{4}D + 21% 5p^2 6p (^{3}P)^{2}S
				+ 8% 5p^2 6p (^{3}P)^{4}P + 7% 5p^2 6p (^{3}P)^{2}P
	-	412618.0	-	49% 5p^2 6p (^{3}P)^{2}S + 39% 5p^2 6p (^{3}P)^{4}D
				+ 11% 5p^2 6p (^{3}P)^{4}P
	-	420153.0	-	76% 5p^2 6p (^{3}P)^{4}P + 13% 5p^2 6p (^{3}P)^{2}S
				+ 7% 5p^2 6p (^{3}P)^{2}P
	-	426905.0	-	99% 4f 5s 5d (^{3}F)^{4}D
	-	429226.0	-	99% 4f 5s 5d (^{3}F)^{4}P
	-	430252.0	-	76% 5p^2 6p (^{3}P)^{2}P + 12% 5p^2 6p (^{3}P)^{2}S
				+ 6% 5p^2 6p (^{3}P)^{4}D
	-	440597.0	-	89% 5p^2 6p (^{1}D)^{2}P
	-	443477.0	-	80% 4f 5s 5d (^{1}F)^{2}P + 18% 4f 5s 5d (^{3}F)^{2}P
	-	455856.0	-	62% 4f 5s 5d (^{3}F)^{2}P + 25% 4f 5p^2 (^{1}D)^{2}P
				+ 11% 4f 5s 5d (^{1}F)^{2}P
	-	457505.0	-	86% 5p^2 6p (^{1}S)^{2}P + 5% 5p^2 6p (^{3}P)^{2}P
3/2	12222.3	12222.0	0.3	98% 5s^2 5p ^{2}P
	204475.2	204356.0	119.2	38% 5p^3 ^{2}D + 28% 5p^3 ^{4}S
				+ 16% 5p^3 ^{2}P + 14% 5s 5p 5d (^{3}P)^{2}D

209983.2	210086.0	-102.8	63% $5p^3$ ^4S + 24% $5p^3$ ^2D
			+ 12% 5s 5p 5d $(^3P)^2D$
215053.6	215052.0	1.6	96% $5s^2$ 6p ^2P
224081.7	223944.0	137.7	94% 5s 5p 5d $(^3P)^4F$
233039.9	232893.0	146.9	56% $5p^3$ ^2P + 16% 5s 5p 5d $(^3P)^2P$
			+ 8% $5p^3$ ^4S + 7% 5s 5p 5d $(^3P)^2D$
237299.3	237254.0	45.3	64% 5s 5p 5d $(^3P)^4D$ + 25% 5s 5p 5d $(^3P)^4P$
246967.2	246815.0	152.2	35% 5s 5p 5d $(^3P)^4P$ + 24% 5s 5p 5d $(^3P)^4D$
			+ 21% 5s 5p 5d $(^3P)^2D$ + 9% $5p^3$ ^2D
248068.1	248089.0	-20.9	36% 5s 5p 5d $(^3P)^4P$ + 33% 5s 5p 5d $(^3P)^2D$
			+ 12% $5p^3$ ^2D + 6% 5s 5p 5d $(^1P)^2D$
264136.8	264251.0	-114.2	76% 5s 5p 6s $(^3P)^4P$ + 9% 5s 5p 6s $(^3P)^2P$
			+ 7% 5s 5p 5d $(^3P)^2P$
266173.1	266531.0	-357.9	46% 5s 5p 5d $(^3P)^2P$ + 22% 5s 5p 5d $(^1P)^2D$
			+ 14% $5p^3$ ^2P + 13% 5s 5p 6s $(^3P)^4P$
277516.3	277792.0	-275.7	51% 5s 5p 6s $(^3P)^2P$ + 25% 5s 5p 5d $(^1P)^2D$
			+ 6% 5s 5p 6s $(^3P)^4P$ + 6% 5s 5p 5d $(^1P)^2P$
280302.5	280231.0	71.5	34% 5s 5p 5d $(^1P)^2D$ + 27% 5s 5p 6s $(^3P)^2P$
			+ 14% 5s 5p 5d $(^3P)^2P$ + 7% 5s 5p 5d $(^3P)^2D$
283800.4	283966.0	-165.6	79% 5s 5p 5d $(^1P)^2P$ + 8% 5s 5p 6s $(^3P)^2P$
295841.7	295901.0	-59.3	83% $5s^2$ 7p ^2P + 12% 5s 5p 6s $(^1P)^2P$
304617.5	304792.0	-174.5	81% 5s 5p 6s $(^1P)^2P$ + 14% $5s^2$ 7p ^2P
335678.6	335522.0	156.6	99% $5s^2$ 8p ^2P
-	388746.0	-	53% 4f $5p^2$ $(^3P)^4F$ + 23% 4f $5p^2$ $(^3P)^4D$
			+ 19% 4f $5p^2$ $(^3P)^2D$ + 4% 4f $5p^2$ $(^1D)^2D$
-	390599.0	-	56% 4f $5p^2$ $(^3P)^4D$ + 21% 4f $5p^2$ $(^1D)^2D$
			+ 9% 4f $5p^2$ $(^3P)^2D$ + 5% 4f $5p^2$ $(^1D)^2P$
-	396619.0	-	57% 4f $5p^2$ $(^3P)^2D$ + 30% 4f $5p^2$ $(^3P)^4F$
			+ 4% 4f $5p^2$ $(^1D)^2P$
-	399531.0	-	46% 4f $5p^2$ $(^1D)^2D$ + 16% 4f 5s 5d $(^3F)^2D$
			+ 14% 4f $5p^2$ $(^3P)^4F$ + 10% 4f $5p^2$ $(^3P)^4D$
-	406699.0	-	57% 4f $5p^2$ $(^1D)^2P$ + 16% 4f 5s 5d $(^3F)^2P$
			+ 10% 4f $5p^2$ $(^3P)^2D$ + 7% 4f 5s 5d $(^1F)^2P$
-	411792.0	-	69% $5p^2$ 6p $(^3P)^4D$ + 15% $5p^2$ 6p $(^3P)^4P$
			+ 6% $5p^2$ 6p $(^3P)^2D$ + 5% $5p^2$ 6p $(^1S)^2P$
-	416135.0	-	29% $5p^2$ 6p $(^3P)^2D$ + 23% $5p^2$ 6p $(^3P)^4D$
			+ 18% $5p^2$ 6p $(^3P)^4P$ + 13% $5p^2$ 6p $(^3P)^4S$
-	417183.0	-	100% 4f 5s 5d $(^3F)^4F$
-	419805.0	-	46% $5p^2$ 6p $(^3P)^4S$ + 32% $5p^2$ 6p $(^3P)^2D$
			+ 12% $5p^2$ 6p $(^1D)^2D$ + 6% $5p^2$ 6p $(^3P)^4P$
-	423172.0	-	51% $5p^2$ 6p $(^3P)^4P$ + 25% $5p^2$ 6p $(^3P)^4S$
			+ 11% $5p^2$ 6p $(^3P)^2D$ + 11% $5p^2$ 6p $(^1D)^2P$

	-	426510.0	-	54% $5p^2$ 6p $(^3P)^2P$ + 27% $5p^2$ 6p $(^1D)^2D$ + 10% $5p^2$ 6p $(^1D)^2P$ + 4% $5p^2$ 6p $(^3P)^2D$
	-	426865.0	-	41% 4f 5s 5d $(^3F)^4D$ + 33% 4f 5s 5d $(^1F)^2D$ + 22% 4f 5s 5d $(^3F)^2D$
	-	427012.0	-	56% 4f 5s 5d $(^3F)^4D$ + 23% 4f 5s 5d $(^1F)^2D$ + 16% 4f 5s 5d $(^3F)^2D$
	-	429128.0	-	97% 4f 5s 5d $(^3F)^4P$
	-	434895.0	-	40% $5p^2$ 6p $(^1D)^2D$ + 28% $5p^2$ 6p $(^1D)^2P$ + 8% $5p^2$ 6p $(^3P)^2D$ + 7% $5p^2$ 6p $(^3P)^2P$
	-	442738.0	-	80% 4f 5s 5d $(^1F)^2P$ + 17% 4f 5s 5d $(^3F)^2P$
	-	445344.0	-	45% $5p^2$ 6p $(^1D)^2P$ + 30% $5p^2$ 6p $(^3P)^2P$ + 11% $5p^2$ 6p $(^1D)^2D$ + 5% $5p^2$ 6p $(^3P)^2D$
	-	450001.0	-	39% 4f 5s 5d $(^1F)^2D$ + 37% 4f 5s 5d $(^3F)^2D$ + 22% 4f $5p^2$ $(^1D)^2D$
	-	456311.0	-	63% 4f 5s 5d $(^3F)^2P$ + 25% 4f $5p^2$ $(^1D)^2P$ + 10% 4f 5s 5d $(^1F)^2P$
	-	460280.0	-	88% $5p^2$ 6p $(^1S)^2P$
5/2	193736.2	193771.0	-34.8	96% 4f $5s^2$ ^2F
	210090.0	210147.0	-57.0	69% $5p^3$ ^2D + 29% 5s 5p 5d $(^3P)^2D$
	226526.5	226489.0	37.5	92% 5s 5p 5d $(^3P)^4F$ + 5% 5s 5p 5d $(^3P)^4D$
	236380.2	236132.0	248.2	52% 5s 5p 5d $(^3P)^4P$ + 32% 5s 5p 5d $(^3P)^4D$ + 6% 5s 5p 5d $(^3P)^2D$ + 5% 5s 5p 5d $(^1P)^2D$
	245330.3	245269.0	61.3	29% 5s 5p 5d $(^3P)^2F$ + 24% 5s 5p 5d $(^3P)^4D$ + 17% 5s 5p 5d $(^3P)^2D$ + 12% 5s 5p 5d $(^1P)^2F$
	246170.9	246725.0	-554.1	38% 5s 5p 5d $(^3P)^4D$ + 30% 5s 5p 5d $(^3P)^4P$ + 22% 5s 5p 5d $(^3P)^2F$ + 7% 5s 5p 5d $(^1P)^2F$
	251761.3	251584.0	177.3	35% 5s 5p 5d $(^3P)^2D$ + 20% 5s 5p 5d $(^3P)^2F$ + 15% 5s 5p 5d $(^3P)^4P$ + 15% 5s 5p 5d $(^1P)^2D$
	274076.4	273919.0	157.4	99% 5s 5p 6s $(^3P)^4P$
	278714.6	278313.0	401.6	40% 5s 5p 5d $(^1P)^2D$ + 31% 5s 5p 5d $(^1P)^2F$ + 8% 5s 5p 5d $(^3P)^2D$ + 6% $5s^2$ 5f ^2F
	281342.5	280952.0	390.5	32% 5s 5p 5d $(^1P)^2D$ + 24% $5s^2$ 5f ^2F + 19% 5s 5p 5d $(^1P)^2F$ + 15% 5s 5p 5d $(^3P)^2F$
	282939.3	282813.0	127.3	69% $5s^2$ 5f ^2F + 21% 5s 5p 5d $(^1P)^2F$ + 6% 5s 5p 5d $(^3P)^2F$
	327788.3	327718.0	70.3	100% $5s^2$ 6f ^2F
	-	352698.0	-	100% $5s^2$ 7f ^2F
	-	378091.0	-	74% 4f $5p^2$ $(^3P)^4G$ + 5% 4f $5p^2$ $(^3P)^2D$ + 5% 4f $5p^2$ $(^1S)^2F$ + 5% 4f $5p^2$ $(^1D)^2F$
	-	385092.0	-	51% 4f $5p^2$ $(^3P)^2D$ + 17% 4f $5p^2$ $(^3P)^4G$ + 12% 4f $5p^2$ $(^1D)^2D$ + 9% 4f $5p^2$ $(^1D)^2F$

	-	387729.0	-	34% 4f 5p^2 (^{3}P)^{4}F + 34% 4f 5p^2 (^{1}D)^{2}F
				+ 23% 4f 5p^2 (^{3}P)^{4}D + 6% 4f 5s 5d (^{3}F)^{2}F
	-	387992.0	-	48% 4f 5p^2 (^{3}P)^{4}D + 19% 4f 5p^2 (^{1}D)^{2}F
				+ 16% 4f 5p^2 (^{1}D)^{2}D + 6% 4f 5p^2 (^{3}P)^{2}D
	-	397052.0	-	53% 4f 5p^2 (^{3}P)^{4}F + 14% 4f 5p^2 (^{3}P)^{2}D
				+ 11% 4f 5p^2 (^{3}P)^{4}D + 11% 4f 5p^2 (^{1}D)^{2}F
	-	401091.0	-	38% 4f 5p^2 (^{1}D)^{2}D + 15% 4f 5s 5d (^{3}F)^{2}D
				+ 14% 4f 5p^2 (^{3}P)^{2}F + 11% 4f 5p^2 (^{3}P)^{4}D
	-	411014.0	-	69% 4f 5p^2 (^{3}P)^{2}F + 10% 4f 5p^2 (^{3}P)^{2}D
				+ 7% 4f 5p^2 (^{1}S)^{2}F + 5% 4f 5p^2 (^{1}D)^{2}D
	-	417358.0	-	100% 4f 5s 5d (^{3}F)^{4}F
	-	417675.0	-	91% 5p^2 6p (^{3}P)^{4}D + 4% 5p^2 6p (^{1}D)^{2}F
	-	419950.0	-	38% 5p^2 6p (^{3}P)^{4}P + 31% 5p^2 6p (^{3}P)^{2}D
				+ 21% 5p^2 6p (^{1}D)^{2}D + 9% 5p^2 6p (^{1}D)^{2}F
	-	423861.0	-	100% 4f 5s 5d (^{3}F)^{4}G
	-	426731.0	-	48% 4f 5s 5d (^{1}F)^{2}D + 33% 4f 5s 5d (^{3}F)^{2}D
				+ 5% 5p^2 6p (^{3}P)^{4}P + 4% 5p^2 6p (^{3}P)^{2}D
	-	427035.0	-	89% 4f 5s 5d (^{3}F)^{4}D
	-	427161.0	-	24% 5p^2 6p (^{3}P)^{4}P + 24% 5p^2 6p (^{3}P)^{2}D
				+ 20% 5p^2 6p (^{1}D)^{2}F + 8% 4f 5s 5d (^{1}F)^{2}D
	-	428913.0	-	57% 4f 5p^2 (^{1}S)^{2}F + 19% 4f 5s 5d (^{3}F)^{4}P
				+ 9% 4f 5s 5d (^{3}F)^{2}F + 8% 4f 5p^2 (^{3}P)^{2}F
	-	429014.0	-	73% 4f 5s 5d (^{3}F)^{4}P + 13% 4f 5p^2 (^{1}S)^{2}F
	-	432017.0	-	83% 4f 5s 5d (^{1}F)^{2}F + 13% 4f 5s 5d (^{3}F)^{2}F
	-	435160.0	-	64% 5p^2 6p (^{1}D)^{2}D + 25% 5p^2 6p (^{3}P)^{4}P
				+ 9% 5p^2 6p (^{1}D)^{2}F
	-	435817.0	-	52% 5p^2 6p (^{1}D)^{2}F + 35% 5p^2 6p (^{3}P)^{2}D
				+ 7% 5p^2 6p (^{1}D)^{2}D + 4% 5p^2 6p (^{3}P)^{4}D
	-	444657.0	-	61% 4f 5s 5d (^{3}F)^{2}F + 21% 4f 5p^2 (^{1}D)^{2}F
				+ 9% 4f 5p^2 (^{1}S)^{2}F + 6% 4f 5s 5d(^{1}F)^{2}F
	-	450583.0	-	38% 4f 5s 5d (^{1}F)^{2}D + 37% 4f 5s 5d (^{3}F)^{2}D
				+ 22% 4f 5p^2 (^{1}D)^{2}D
7/2	194044.9	194019.0	25.9	96% 4f 5s^2 ^{2}F
	230308.9	230462.0	-153.1	90% 5s 5p 5d (^{3}P)^{4}F + 8% 5s 5p 5d (^{3}P)^{4}D
	244734.9	245180.0	-445.1	90% 5s 5p 5d (^{3}P)^{4}D + 9% 5s 5p 5d (^{3}P)^{4}F
	258571.0	258507.0	64.0	73% 5s 5p 5d (^{3}P)^{2}F + 24% 5s 5p 5d (^{1}P)^{2}F
	278129.2	277982.0	147.2	63% 5s 5p 5d (^{1}P)^{2}F + 23% 5s 5p 5d (^{3}P)^{2}F
				+ 8% 5s^2 5f ^{2}F
	282416.1	282656.0	-239.9	91% 5s^2 5f ^{2}F + 8% 5s 5p 5d (^{1}P)^{2}F
	327730.9	327803.0	-72.1	100% 5s^2 6f ^{2}F
	-	352748.0	-	100% 5s^2 7f ^{2}F

	-	379931.0	-	29% 4f $5p^2$ $(^3P)^4G$ + 17% 4f $5p^2$ $(^3P)^2G$
				+ 16% 4f $5p^2$ $(^1D)^2G$ + 13% 4f $5p^2$ $(^3P)^4D$
	-	381028.0	-	41% 4f $5p^2$ $(^1D)^2G$ + 39% 4f $5p^2$ $(^3P)^4G$
				+ 10% 4f $5p^2$ $(^3P)^2G$ + 7% 4f 5s 5d $(^3F)^2G$
	-	385507.0	-	51% 4f $5p^2$ $(^3P)^4D$ + 22% 4f $5p^2$ $(^3P)^4G$
				+ 17% 4f $5p^2$ $(^1D)^2F$
	-	387885.0	-	44% 4f $5p^2$ $(^1D)^2F$ + 25% 4f $5p^2$ $(^3P)^4F$
				+ 16% 4f $5p^2$ $(^3P)^4D$ + 8% 4f 5s 5d $(^3F)^2F$
	-	397979.0	-	60% 4f $5p^2$ $(^3P)^4F$ + 14% 4f $5p^2$ $(^3P)^4D$
				+ 9% 4f $5p^2$ $(^1D)^2F$ + 7% 4f $5p^2$ $(^3P)^2G$
	-	398903.0	-	55% 4f $5p^2$ $(^3P)^2G$ + 18% 4f $5p^2$ $(^1D)^2G$
				+ 8% 4f 5s 5d $(^3F)^2G$ + 8% 4f $5p^2$ $(^3P)^2F$
	-	414131.0	-	83% 4f $5p^2$ $(^3P)^2F$ + 5% 4f 5s 5d $(^3F)^2G$
				+ 4% 4f $5p^2$ $(^3P)^2G$
	-	415867.0	-	99% 4f 5s 5d $(^3F)^4H$
	-	417600.0	-	99% 4f 5s 5d $(^3F)^4F$
	-	421170.0	-	52% 4f 5s 5d $(^1F)^2G$ + 40% 4f 5s 5d $(^3F)^2G$
				+ 5% 4f $5p^2$ $(^1D)^2G$
	-	422382.0	-	79% 5p2 6p $(^3P)^4D$ + 19% $5p^2$ 6p $(^1D)^2F$
	-	424169.0	-	100% 4f 5s 5d $(^3F)^4G$
	-	427220.0	-	95% 4f 5s 5d $(^3F)^4D$
	-	427602.0	-	78% 4f $5p^2$ $(^1S)^2F$ + 8% 4f 5s 5d $(^3F)^2F$
	-	432320.0	-	82% 4f 5s 5d $(^1F)^2F$ + 14% 4f 5s 5d $(^3F)^2F$
	-	437074.0	-	79% $5p^2$ 6p $(^1D)^2F$ + 19% $5p^2$ 6p $(^3P)^4D$
	-	444577.0	-	61% 4f 5s 5d $(^3F)^2F$ + 21% 4f $5p^2$ $(^1D)^2F$
				+ 8% 4f $5p^2$ $(^1S)^2F$ + 7% 4f 5s 5d $(^1F)^2F$
	-	444870.0	-	45% 4f 5s 5d $(^1F)^2G$ + 37% 4f 5s 5d $(^3F)^2G$
				+ 16% 4f $5p^2$ $(^1D)^2G$
9/2	-	237428.0	-	100% 5s 5p 5d $(^3P)^4F$
	-	383143.0	-	52% 4f $5p^2$ $(^1D)^2G$ + 23% 4f $5p^2$ $(^3P)^4G$
				+ 9% 4f 5s 5d $(^3F)^2G$ + 7% 4f $5p^2$ $(^3P)^2G$
	-	385068.0	-	64% 4f $5p^2$ $(^3P)^4G$ + 17% 4f $5p^2$ $(^3P)^4F$
				+ 10% 4f $5p^2$ $(^1D)^2G$ + 5% 4f $5p^2$ $(^3P)^2G$
	-	392065.0	-	63% 4f $5p^2$ $(^1D)^2H$ + 11% 4f 5s 5d $(^3F)^2H$
				+ 9% 4f $5p^2$ $(^3P)^2G$ + 7% 4f 5s 5d $(^1F)^2H$
	-	397826.0	-	80% 4f $5p^2$ $(^3P)^4F$ + 8% 4f $5p^2$ $(^3P)^4G$
				+ 7% 4f $5p^2$ $(^1D)^2G$
	-	404099.0	-	76% 4f $5p^2$ $(^3P)^2G$ + 7% 4f $5p^2$ $(^1D)^2H$
				+ 5% 4f $5p^2$ $(^1D)^2G$
	-	416267.0	-	100% 4f 5s 5d $(^3F)^4H$
	-	417894.0	-	99% 4f 5s 5d $(^3F)^4F$

	-	421291.0	-	50% 4f 5s 5d $(^1F)^2G$ + 43% 4f 5s 5d $(^3F)^2G$
				+ 5% 4f $5p^2$ $(^1D)^2G$
	-	424550.0	-	100% 4f 5s 5d $(^3F)^4G$
	-	434783.0	-	90% 4f 5s 5d $(^1F)^2H$ + 9% 4f $5p^2$ $(^1D)^2H$
	-	445198.0	-	48% 4f 5s 5d $(^1F)^2G$ + 36% 4f 5s 5d $(^3F)^2G$
				+ 15% 4f $5p^2$ $(^1D)^2G$
	-	447372.0	-	85% 4f 5s 5d $(^3F)^2H$ + 15% 4f $5p^2$ $(^1D)^2H$
11/2	-	386682.0	-	67% 4f $5p^2$ $(^3P)^4G$ + 27% 4f $5p^2$ $(^1D)^2H$
	-	396566.0	-	49% 4f $5p^2$ $(^1D)^2H$ + 33% 4f $5p^2$ $(^3P)^4G$
				+ 11% 4f 5s 5d $(^3F)^2H$ + 7% 4f 5s 5d $(^1F)^2H$
	-	416763.0	-	100% 4f 5s 5d $(^3F)^4H$
	-	424990.0	-	100% 4f 5s 5d $(^3F)^4G$
	-	435770.0	-	91% 4f 5s 5d $(^1F)^2H$ + 8% 4f $5p^2$ $(^1D)^2H$
	-	447297.0	-	84% 4f 5s 5d $(^3F)^2H$ + 15% 4f $5p^2$ $(^1D)^2H$
13/2	-	417350.0	-	100% 4f 5s 5d $(^3F)^4H$

Table 5.3. Observed and fitted energy levels (in cm^{-1}) for even parity configurations of I V spectrum

J	E(obs)	E(LSF)	diff.	LS-composition.
1/2	81003.3	81117.0	-113.7	96% 5s 5p^2 (^{3}P)^{4}P
	125703.3	125519.0	184.3	61% 5s 5p^2 (^{3}P)^{2}P + 35% 5s 5p^2 (^{1}S)^{2}S
	138329.0	138428.0	-99.0	61% 5s 5p^2 (^{1}S)^{2}S + 37% 5s 5p^2 (^{3}P)^{2}P
	176814.7	176815.0	0.3	99% 5s^2 6s ^{2}S
	274857.3	274857.0	0.3	100% 5s^2 7s ^{2}S
	-	285175.0	-	99% 4f 5s 5p (^{3}F)^{4}D
	322326.2	322326.0	0.2	100% 5s^2 8s ^{2}S
	342650.3	342738.0	-87.7	82% 5p^2 5d (^{3}P)^{4}D + 13% 5p^2 5d (^{3}P)^{2}P
	349192.6	349193.0	-0.4	100% 5s^2 9s ^{2}S
	354017.7	354027.0	-9.3	72% 5p^2 5d (^{3}P)^{2}P + 14% 5p^2 5d (^{3}P)^{4}D
				+ 7% 5p^2 5d (^{1}D)^{2}P
	359464.4	359568.0	-103.4	86% 5p^2 5d (^{3}P)^{4}P + 5% 5p^2 5d (^{1}D)^{2}S
				+ 4% 5p^2 5d (^{3}P)^{2}P
	376631.4	376372.0	259.4	57% 5p^2 6s (^{3}P)^{4}P + 16% 5p^2 5d (^{1}D)^{2}P
				+ 13% 5p^2 6s (^{3}P)^{2}P + 6% 5p^2 5d (^{1}D)^{2}S
	378849.5	378742.0	107.5	40% 5p^2 5d (^{1}D)^{2}P + 32% 5p^2 5d (^{1}D)^{2}S
				+ 25% 5p^2 6s (^{3}P)^{4}P
	380713.7	380852.0	-138.3	54% 5p^2 5d (^{1}D)^{2}S + 26% 5p^2 5d (^{1}D)^{2}P
				+ 9% 5p^2 5d (^{3}P)^{4}P + 7% 5p^2 5d (^{3}P)^{2}P
	387717.1	387862.0	-144.9	81% 5p^2 6s (^{3}P)^{2}P + 11% 5p^2 6s (^{3}P)^{4}P
				+ 5% 5p^2 5d (^{1}D)^{2}P
	421258.3	421274.0	-15.7	91% 5p^2 6s (^{1}S)^{2}S + 4% 5p^2 6s (3P)^{4}P
3/2	86898.7	86959.0	-60.3	99% 5s 5p^2 (^{3}P)^{4}P
	108780.7	108938.0	-157.3	89% 5s 5p^2 (^{1}D)^{2}D + 6% 5s^2 5d ^{2}D
	139399.0	139473.0	-74.0	94% 5s 5p^2 (^{3}P)^{2}P
	154049.7	154035.0	14.7	89% 5s^2 5d ^{2}D + 7% 5s 5p^2(^{1}D)^{2}D
	264428.0	264427.0	1.0	97% 5s^2 6d ^{2}D
	-	270542.0	-	91% 4f 5s 5p (^{3}F)^{4}F + 4% 4f 5s 5p (^{3}F)^{4}D
	-	284390.0	-	94% 4f 5s 5p (^{3}F)^{4}D + 5% 4f 5s 5p (^{3}F)^{4}F
	-	295943.0	-	75% 4f 5s 5p (^{1}F)^{2}D + 19% 4f 5s 5p (^{3}F)^{2}D
	317717.0	317859.0	-142.0	53% 5s^2 7d ^{2}D + 32% 4f 5s 5p (^{3}F)^{2}D
				+ 12% 4f 5s 5p (^{1}F)^{2}D
	-	323824.0	-	47% 5s^2 7d ^{2}D + 41% 4f 5s 5p (^{3}F)^{2}D
				+ 8% 4f 5s 5p (^{1}F)^{2}D

	332275.2	332572.0	-296.8	77% 5p^2 5d (^{3}P)^{4}F + 8% 5p^2 5d (^{3}P)^{4}D
				+ 5% 5p^2 5d (^{1}S)^{2}D + 4% 5p^2 5d (^{3}P)^{2}P
	341092.3	341321.0	-228.7	48% 5p^2 5d (^{3}P)^{2}P + 24% 5p^2 5d (^{3}P)^{4}D
				+ 15% 5p^2 5d (^{3}P)^{4}F + 9% 5p^2 5d (^{1}D)^{2}P
	346921.9	346848.0	73.9	58% 5p^2 5d (^{3}P)^{4}D + 27% 5p^2 5d (^{3}P)^{2}P
				+ 5% 5p^2 5d (^{1}D)^{2}P
	358382.2	358080.0	302.2	81% 5p^2 5d (^{3}P)^{4}P + 8% 5p^2 5d (^{1}D)^{2}D
				+ 6% 5p^2 5d (^{1}D)^{2}P
	368057.2	368045.0	12.2	53% 5p^2 5d (^{1}D)^{2}D + 13% 5p^2 5d (^{1}S)^{2}D
				+ 12% 5p^2 5d (^{3}P)^{2}D + 9% 5p^2 5d (^{3}P)^{4}P
	370576.5	370393.0	183.5	41% 5p^2 5d (^{3}P)^{2}D + 33% 5p^2 5d (^{1}D)^{2}D
				+ 16% 5p^2 5d (^{1}S)^{2}D + 4% 5p^2 5d (^{1}D)^{2}P
	383180.2	383215.0	-34.8	78% 5p^2 6s (^{3}P)^{4}P + 10% 5p^2 5d (^{1}D)^{2}P
				+ 8% 5p^2 6s (^{3}P)^{2}P
	385129.7	385291.0	-161.3	56% 5p^2 5d (^{1}D)^{2}P + 17% 5p2 6s (^{3}P)^{4}P
				+ 13% 5p^2 5d (^{3}P)^{2}P
	392659.8	392542.0	117.8	59% 5p^2 6s (^{3}P)^{2}P + 33% 5p2 6s (^{1}D)^{2}D
				+ 4% 5p^2 5d (^{1}D)^{2}P
	401486.9	401654.0	-167.1	54% 5p^2 5d (^{1}S)^{2}D + 38% 5p2 5d (^{3}P)^{2}D
	404290.7	404213.0	77.7	65% 5p^2 6s (^{1}D)^{2}D + 30% 5p2 6s (^{3}P)^{2}P
5/2	92554.5	92388.0	166.5	90% 5s 5p^2 (^{3}P)^{4}P + 9% 5s 5p^2 (^{1}D)^{2}D
	111831.6	111681.0	150.6	83% 5s 5p^2 (^{1}D)^{2}D + 10% 5s 5p^2 (^{3}P)^{4}P
				+ 6% 5s^2 5d ^{2}D
	155461.8	155474.0	-12.2	91% 5s^2 5d ^{2}D + 6% 5s 5p^2 (^{1}D)^{2}D
	265083.0	265084.0	-1.0	97% 5s^2 6d ^{2}D
	-	267814.0	-	62% 4f 5s 5p (^{3}F)^{4}G + 21% 4f 5s 5p (^{3}F)^{4}F
				+ 8% 4f 5s 5p (^{1}F)^{2}F + 6% 4f 5s 5p (^{3}F)^{2}F
	-	270558.0	-	48% 4f 5s 5p (^{3}F)^{4}F + 24% 4f 5s 5p (^{1}F)^{2}F
				+ 14% 4f 5s 5p (^{3}F)^{2}F + 9% 4f 5s 5p (^{3}F)^{4}D
	-	274288.0	-	34% 4f 5s 5p (^{3}F)^{4}G + 33% 4f 5s 5p (^{1}F)^{2}F
				+ 16% 4f 5s 5p (^{3}F)^{4}F + 7% 4f 5s 5p (^{3}F)^{2}F
	-	283027.0	-	84% 4f 5s 5p (^{3}F)^{4}D + 12% 4f 5s 5p (^{3}F)^{4}F
	-	291381.0	-	74% 4f 5s 5p (^{1}F)^{2}D + 11% 4f 5s 5p (^{3}F)^{2}D
				+ 7% 4f 5s 5p (^{3}F)^{2}F
	-	309243.0	-	64% 4f 5s 5p (^{3}F)^{2}F + 29% 4f 5s 5p (^{1}F)^{2}F
	318413.6	318284.0	129.6	58% 5s^2 7d ^{2}D + 33% 4f 5s 5p (^{3}F)^{2}D
				+ 6% 4f 5s 5p (^{1}F)^{2}D
	-	324599.0	-	48% 4f 5s 5p (^{3}F)^{2}D + 42% 5s^2 7d ^{2}D
				+ 6% 4f 5s 5p (^{1}F)^{2}D
	336019.0	335932.0	87.0	75% 5p^2 5d (^{3}P)^{4}F + 16% 5p^2 5d (^{3}P)^{4}D
	341777.2	341658.0	119.2	41% 5p^2 5d (^{1}D)^{2}F + 28% 5p^2 5d (^{3}P)^{2}F

				+ 15% $5p^2$ 5d $(^3P)^4D$ + 12% $5p^2$ 5d $(^3P)^4F$
	347709.6	347746.0	-36.4	50% $5p^2$ 5d $(^3P)^4D$ + 14% $5p^2$ 5d $(^1D)^2F$
				+ 13% $5p^2$ 5d $(^3P)^2F$ + 11% $5p^2$ 5d $(^3P)^4P$
	355531.4	355419.0	112.4	70% $5p^2$ 5d $(^3P)^4P$ + 17% $5p^2$ 5d $(^1D)^2D$
				+ 11% $5p^2$ 5d $(^3P)^4D$
	367570.5	367663.0	-93.5	60% $5p^2$ 5d $(^1D)^2D$ + 15% $5p^2$ 5d $(^3P)^2D$
				+ 12% $5p^2$ 5d $(^3P)^4P$ + 5% $5p^2$ 5d $(^1S)^2D$
	379827.4	379690.0	137.4	47% $5p^2$ 5d $(^3P)^2D$ + 19% $5p^2$ 5d $(^3P)^2F$
				+ 13% $5p^2$ 5d $(^1D)^2F$ + 12% $5p^2$ 5d $(^1D)^2D$
	384223.5	384530.0	-306.5	36% $5p^2$ 5d $(^1S)^2D$ + 23% $5p^2$ 5d $(^1D)^2F$
				+ 19% $5p^2$ 5d $(^3P)^2F$ + 7% $5p^2$ 5d $(^1D)^2D$
	388394.5	388505.0	-110.5	79% $5p^2$ 6s $(^3P)^4P$ + 17% $5p^2$ 6s $(^1D)^2D$
	399672.4	399249.0	423.4	44% $5p^2$ 5d $(^1S)^2D$ + 28% $5p^2$ 5d $(^3P)^2D$
				+ 14% $5p^2$ 5d $(^3P)^2F$ + 8% $5p^2$ 5d $(^1D)^2F$
	402880.3	402963.0	-82.7	80% $5p^2$ 6s $(^1D)^2D$ + 19% $5p^2$ 6s $(^3P)^4P$
7/2	-	268865.0	-	50% 4f 5s 5p $(^3F)^4F$ + 42% 4f 5s 5p $(^3F)^4G$
				+ 6% 4f 5s 5p $(^3F)^4D$
	-	271059.0	-	35% 4f 5s 5p $(^1F)^2F$ + 25% 4f 5s 5p $(^3F)^2F$
				+ 16% 4f 5s 5p $(^3F)^4G$ + 14% 4f 5s 5p $(^3F)^4D$
	-	276058.0	-	37% 4f 5s 5p $(^3F)^4G$ + 23% 4f 5s 5p $(^3F)^4F$
				+ 23% 4f 5s 5p $(^1F)^2F$ + 5% 4f 5s 5p $(^1F)^2G$
	-	281250.0	-	71% 4f 5s 5p $(^3F)^4D$ + 19% 4f 5s 5p $(^3F)^4F$
	-	287222.0	-	79% 4f 5s 5p $(^1F)^2G$ + 7% 4f 5s 5p $(^3F)^2F$
				+ 6% 4f 5s 5p $(^3F)^2G$
	296484.1	296526.0	-41.9	92% $5s^2$ 5g ^2G + 7% 4f 5s 5p $(^3F)^2G$
	-	309555.0	-	62% 4f 5s 5p $(^3F)^2F$ + 32% 4f 5s 5p $(^1F)^2F$
	-	314571.0	-	77% 4f 5s 5p $(^3F)^2G$ + 8% $5s^2$ 5g ^2G
				+ 5% $5p^2$ 5d $(^1D)^2G$ + 4% $5s^2$ 6g ^2G
	333012.0	333033.0	-21.0	95% $5s^2$ 6g ^2G + 4% spf (^2F) ^2G
	340793.6	340801.0	-7.4	84% $5p^2$ 5d $(^3P)^4F$ + 14% $5p^2$ 5d $(^3P)^4D$
	344812.7	344753.0	59.7	39% $5p^2$ 5d $(^3P)^4D$ + 34% $5p^2$ 5d $(^1D)^2F$
				+ 16% $5p^2$ 5d $(^3P)^2F$ + 7% $5p^2$ 5d $(^3P)^4F$
	356100.7	356006.0	94.7	46% $5p^2$ 5d $(^3P)^4D$ + 21% $5p^2$ 5d $(^1D)^2F$
				+ 19% $5p^2$ 5d $(^3P)^2F$ + 7% $5p^2$ 5d $(^3P)^4F$
	-	362432.0	-	78% $5s^2$ 7g ^2G + 18% $5p^2$ 5d$(^1D)^2G$
	364939.0	364654.0	285.0	63% $5p^2$ 5d $(^1D)^2G$ + 21% $5s^2$ 7g ^2G
				+ 8% $5p^2$ 5d $(^1D)^2F$
	386939.9	387225.0	-285.1	60% $5p^2$ 5d $(^3P)^2F$ + 32% $5p^2$ 5d $(^1D)^2F$
9/2	-	271060.0	-	58% 4f 5s 5p $(^3F)^4F$ + 39% 4f 5s 5p $(^3F)^4G$
	-	278237.0	-	60% 4f 5s 5p $(^3F)^4G$ + 40% 4f 5s 5p $(^3F)^4F$

	-	293635.0	-	83% 4f 5s 5p $(^1F)^2G$ + 14% 4f 5s 5p $(^3F)^2G$
	296481.1	296438.0	43.1	91% $5s^2$ 5g ^2G + 6% 4f 5s 5p $(^3F)^2G$
	-	313451.0	-	71% 4f 5s 5p $(^3F)^2G$ + 9% 4f 5s 5p $(^1F)^2G$
				+ 9% $5s^2$ 5g ^2G + 5% $5p^2$ 5d $(^1D)^2G$
	333002.2	332982.0	20.2	96% $5s^2$ 6g ^2G + 4% spf (^2F) ^2G
	345804.1	345710.0	94.1	90% $5p^2$ 5d $(^3P)^4F$ + 8% $5p^2$ 5d $(^1D)^2G$
	-	362704.0	-	95% $5s^2$ 7g ^2G
	366999.0	367188.0	-189.0	81% $5p^2$ 5d $(^1D)^2G$ + 8% $5p^2$ 5d $(^3P)^4F$
				+ 4% $5s^2$ 7g ^2G
11/2	-	279453.0	-	100% 4f 5s 5p $(^3F)^4G$

Table 5.4. Least Squares Fitted Energy parameters (in cm^{-1}) for odd parity configurations of I V

Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$5s^2$ 5p	E_{av} (5s2 5p)	12709.5	249.0	12752.0	
	ζ_{5p}	8280.8	276.0	7730.7	1.071
$5s^2$ 6p	E_{av} (5s2 6p)	218810.8	225.0	219793.4	0.995
	ζ_{6p}	2610.9	281.0	2386.4	1.094
$5s^2$ 7p	E_{av} (5s2 7p)	296054.2	257.0	297322.8	0.996
	ζ_{7p}	1234.9	(fixed)	1127.4	1.095
$5s^2$ 8p	E_{av} (5s2 8p)	334986.7	205.0	336521.0	0.995
	ζ_{8p}	687.9	(fixed)	628.9	1.094
4f 5s	E_{av} (4f 5s2)	200134.2	223.0	199503.0	1.004
	ζ_{4f}	91.0	(fixed)	91.0	1.000
$5s^2$ 5f	E_{av} (5s2 5f)	282076.7	254.0	280587.9	1.006
	ζ_{5f}	46.9	(fixed)	46.9	1.000
$5s^2$ 6f	E_{av} (5s2 6f)	327599.7	204.0	326106.9	1.005
	ζ_{6f}	24.5	(fixed)	24.5	1.000
$5s^2$ 7f	E_{av} (5s2 7f)	352639.2	(fixed)	352641.4	1.006
	ζ_{7f}	14.4	(fixed)	14.4	1.000
5s 5p 5d	E_{av} (5s 5p 5d)	252054.7	96.0	248632.4	1.015
	ζ_{5p}	9353.7	183.0	7914.9	1.182
	ζ_{5d}	587.2	102.0	516.4	1.137
	F^2(5p, 5d)	39594.1	852.0	41671.1	0.950
	G^1(5s, 5p)	44697.5	418.0	69847.9	0.640
	G^2(5s, 5d)	20821.9	803.0	30314.3	0.687
	G^1(5p, 5d)	38455.5	553.0	47678.4	0.807
	G^3(5p, 5d)	27291.5	1284.0	30268.4	0.902
5s 5p 6s	E_{av} (5s 5p 6s)	279882.6	143.0	277273.8	1.010
	ζ_{5p}	8871.8	237.0	8177.1	1.085
	G^1(5s, 5p)	46648.4	508.0	70473.2	0.662
	G^0(5s, 6s)	2784.6	236.0	4335.8	0.642
	G^1(5p, 6s)	4309.6	(fixed)	6630.5	0.650
$5p^3$	E_{av} ($5p^3$)	225546.8	289.0	228122.5	0.988
	F2(5p, 5p)	41277.9	978.0	53028.1	0.778
	α_{5p}	0.0	(fixed)		
	ζ_{5p}	8368.4	251.0	7632.8	1.096
4f $5p^2$	E_{av} (4f 5p2)	398335.1	(fixed)	398336.0	1.000
	F^2(5p, 5p)	44810.7	(fixed)	52718.5	0.850
	α_{5p}	-200.0	(fixed)		
	ζ_{4f}	108.2	(fixed)	108.2	1.000
	ζ_{5p}	7497.4	(fixed)	7497.4	1.000

	F^2(4f, 5p)	39220.5	(fixed)	46141.8	0.850
	G^2(4f, 5p)	28382.4	(fixed)	37843.3	0.750
	G^4(4f, 5p)	19961.2	(fixed)	26615.0	0.750
4f 5s 5d	E_{av} (4f 5s 5d)	426938.7	(fixed)	426944.5	1.000
	ζ_{4f}	113.4	(fixed)	113.4	1.000
	ζ_{5d}	497.2	(fixed)	497.2	1.000
	$F^{2($ 4f, 5d)	29440.7	(fixed)	34636.1	0.850
	$F^{4($ 4f, 5d)	17897.9	(fixed)	21056.4	0.850
	$G^{3($ 4f, 5s)	26055.2	(fixed)	34740.3	0.750
	$G^{1($ 4f, 5d)	23588.1	(fixed)	31450.9	0.750
	$G^{3($ 4f, 5d)	16407.7	(fixed)	21877.0	0.750
	$G^{5($ 4f, 5d)	11982.5	(fixed)	15976.8	0.750
	$G^{2($ 5s, 5d)	22213.0	(fixed)	29617.3	0.750
$5s^2$ 5p -5s 5p 5d	R^1(5s, 5p; 5p, 5d)	39239.6	560.0	55775.4	0.704
	R^2(5s, 5p; 5d, 5p)	28351.2	404.0	40298.8	0.704
$5s^2$ 5p -5s 5p 6s	R^0(5s, 5s; 5s, 6s)	2488.4	35.0	3537.8	0.703
	R^1(5s, 5p; 5p, 6s)	-600.0	-9.0	-853.0	0.703
	R^0(5s, 5p; 6s, 5p)	-39.4	-1.0	-56.0	0.704
$5s^2$ 5p -$5p^3$	R^1(5s, 5s; 5p, 5p)	48701.0	695.0	69224.4	0.704
$5s^2$ 5p -$5p^2$ 6p	R^1(5s, 5s; 5p, 6p)	11652.8	(fixed)	16646.4	0.700
$5s^2$ 5p -4f 5s 5d	R^3(5s, 5p; 4f, 5d)	-19663.9	(fixed)	-28090.5	0.700
	R^2(5s, 5p; 5d, 4f)	-22572.8	(fixed)	-32246.4	0.700
$5s^2$ 6p -5s 5p 5d	R^1(5s, 6p; 5p, 5d)	-3166.4	-45.0	-4501.9	0.703
	R^2(5s, 6p; 5d, 5p)	3884.9	55.0	5523.5	0.703
$5s^2$ 6p -5s 5p 6s	R^1(5s, 6p; 5p, 6s)	21359.3	305.0	30368.0	0.703
	R^0(5s, 6p; 6s, 5p)	2877.8	41.0	4091.5	0.703
$5s^2$ 6p -$5p^2$ 6p	R^1(5s, 5s; 5p, 5p)	53288.3	(fixed)	71051.1	0.750
$5s^2$ 6p -4f 5s 5d	R^3(5s, 6p; 4f, 5d)	-224.1	(fixed)	-298.8	0.750
	R^2(5s, 6p; 5d, 4f)	-1813.8	(fixed)	-2418.4	0.750
$5s^2$ 7p -5s 5p 5d	R^1(5s, 7p; 5p, 5d)	-2067.9	-29.0	-2940.0	0.703
	R^2(5s, 7p; 5d, 5p)	1405.1	20.0	1997.7	0.703
$5s^2$ 7p -5s 5p 6s	R^1(5s, 7p; 5p, 6s)	9779.2	139.0	13903.8	0.703
	R^0(5s, 7p; 6s, 5p)	1733.0	25.0	2464.0	0.703
$5s^2$ 7p -4f 5s 5d	R^2(5s, 7p; 5d, 4f)	601.0	(fixed)	801.4	0.750
	R^1(5s, 8p; 5p, 5d)	-658.6	(fixed)	-878.1	0.750
$5s^2$ 8p -5s 5p 5d	R^2(5s, 8p; 5d, 5p)	-1549.6	-22.0	-2203.2	0.703
	R^1(5s, 8p; 5p, 6s)	693.0	10.0	985.2	0.703
$5s^2$ 8p -5s 5p 6s	R^0(5s, 8p; 6s, 5p)	6256.2	89.0	8894.9	0.703
	R^3(5s, 8p; 4f, 5d)	1209.2	17.0	1719.2	0.703
4f $5s^2$ -5s 5p 5d	R^2(4f, 5s; 5p, 5d)	642.8	(fixed)	857.1	0.750
	R^1(4f, 5s; 5d, 5p)	-324.5	(fixed)	-432.7	0.750
4f $5s^2$ -4f $5p^2$	R^1(5s, 5s; 5p, 5p)	-23265.0	-332.0	-33077.6	0.703
	R^2(4f, 5s; 4f, 5d)	-30578.1	-436.0	-43475.0	0.703
4f $5s^2$ -4f 5s 5d	R^3(4f, 5s; 5d, 4f)	51560.5	(fixed)	68747.3	0.750
$5s^2$ 5f -5s 5p 5d	R^1(5s, 5f; 5p, 5d)	25177.1	(fixed)	33569.5	0.750
	R^2(5s, 5f; 5d, 5p)	18202.5	(fixed)	24269.9	0.750

$5s^2 5f$ -$4f 5s 5d$	R^3(5s, 5f; 4f, 5d)	2562.2	37.0	3642.9	0.703
	R^2(5s, 5f; 5d, 4f)	-4214.4	-60.0	-5991.9	0.703
$5s^2 6f$ -$5s 5p 5d$	R^1(5s, 6f; 5p, 5d)	1569.2	(fixed)	2092.3	0.750
	R^2(5s, 6f; 5d, 5p)	5656.2	(fixed)	7541.6	0.750
$5s^2 6f$ -$4f 5s 5d$	R^3(5s, 6f; 4f, 5d)	5699.2	81.0	7560.8	0.703
	R^2(5s, 6f; 5d, 4f)	-105.9	-2.0	-140.6	0.703
$5s^2 7f$ -$5s 5p 5d$	R^1(5s, 7f; 5p, 5d)	-1158.4	(fixed)	-1544.6	0.750
	R^2(5s, 7f; 5d, 5p)	1634.0	(fixed)	2178.6	0.750
5s2 7f -4f 5s 5d	R^3(5s, 7f; 4f, 5d)	5302.9	(fixed)	7070.5	0.750
	R^2(5s, 7f; 5d, 4f)	961.8	(fixed)	1282.4	0.750
5s 5p 5d –5s 5p 6s	R^2(5p, 5d; 5p, 6s)	-1583.0	(fixed)	-2110.7	0.750
	R^1(5p, 5d; 6s, 5p)	482.8	(fixed)	643.7	0.750
$5s 5p 5d$ -$5p^3$	R^1(5s, 5d; 5p, 5p)	-8981.4	-128.0	-12769.4	0.703
	R^3(5s, 5d; 4f, 5p)	-3434.4	-49.0	-4882.9	0.703
$5s 5p 5d$ -$4f 5p^2$	R^1(5s, 5d; 5p, 4f)	38920.4	555.0	55335.9	0.703
$5s 5p 5d$ -$5p^2 6p$	R^1(5s, 5d; 5p, 6p)	-21285.2	(fixed)	-28380.3	0.750
	R^1(5s, 5d; 6p, 5p)	-31228.2		-41637.6	0.750
5s 5p 5d -4f 5s 5d	R^2(5p, 5d; 4f, 5d)	-4169.1	(fixed)	-5558.8	0.750
	R^4(5p, 5d; 4f, 5d)	8015.2	(fixed)	10686.9	0.750
5s 5p 5d -4f 5s 5d	R^1(5p, 5d; 5d, 4f)	-25599.3	(fixed)	-34132.5	0.750
	R^3(5p, 5d; 5d, 4f)	-16711.2	(fixed)	-22281.6	0.750
	R^1(5s, 6s; 5p, 5p)	-27661.6	(fixed)	-36882.1	0.750
	R^1(5s, 6s; 5p, 6p)	-18292.6	(fixed)	-24390.1	0.750
$5s 5p 6s$ -$5p^2 6p$	R^1(5s, 6s; 6p, 5p)	-471.3	-7.0	-670.0	0.703
5s 5p 6s -4f 5s 5d	R^2(5p, 6s; 4f, 5d)	23085.0	(fixed)	30780.0	0.750
	R^3(5p, 6s; 5d, 4f)	3124.5	(fixed)	4165.9	0.750
$5p^3$ -$4f 5p^2$	R^2(5p, 5p; 4f, 5p)	9024.8	(fixed)	12033.0	0.750
	R^0(5p, 5p; 5p, 6p)	3396.8	(fixed)	4529.1	0.750
$5p^3$ -$5p^2 6p$	R^2(5p, 5p; 5p, 6p)	-32485.4	(fixed)	-43313.9	0.750
$4f 5p^2$ -$5p^2 6p$	R^2(4f, 5p; 5p, 6p)	1284.5	(fixed)	1712.7	0.750
	R^2(4f, 5p; 6p, 5p)	5982.2	(fixed)	7976.3	0.750
$4f 5p^2$ -$4f 5s 5d$	R^1(5p, 5p; 5s, 5d)	-4193.9	(fixed)	-5591.8	0.750
	σ	288			

The R^k parameters for known configurations were linked together to vary in the same ratio while for unknown configurations they are held fixed at 75% of HFR values.

Table 5.5. Least Square Fitted energy parameters (in cm^{-1}) for even parity configurations of I V

Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$5s\,5p^2$	E_{av} $(5s\,5p^2)$	111280.7	270.0	110253.6	1.011
	F^2(5p, 5p)	40938.9	624.0	53019.0	0.772
	α_{5p}	-256.0	-102.0		
	ζ_{5p}	8340.1	126.0	7677.8	1.086
	G^1(5s, 5p)	48744.9	420.0	69164.6	0.705
$5s^2\,5d$	E_{av} $(5s^2\,5d)$	156375.4	186.0	157473.6	0.993
	ζ_{5d}	667.8	128.0	499.3	1.337
$5s^2\,6d$	E_{av} $(5s^2\,6d)$	265409.7	152.0	271106.6	0.978
	ζ_{6d}	249.0	119.0	207.4	1.201
$5s^2\,7d$	E_{av} $(5s^2\,7d)$	320719.7	262.0	322694.1	0.994
	ζ_{7d}	129.5	(fixed)	107.9	1.200
$5s^2\,6s$	E_{av} $(5s^2\,6s)$	179454.5	337.0	182899.7	0.980
$5s^2\,7s$	E_{av} $(5s^2\,7s)$	274854.2	204.0	280192.8	0.980
$5s^2\,8s$	E_{av} $(5s^2\,8s)$	322324.6	204.0	327105.5	0.985
$5s^2\,9s$	E_{av} $(5s^2\,9s)$	349191.2	204.0	353607.1	0.987
$5p^2\,5d$	E_{av} (5p2 5d)	359390.4	61.0	360279.1	0.998
	F^2(5p, 5p)	47591.9	688.0	53587.9	0.898
	α_{5p}	-171.4	-39.0		
	ζ_{5p}	8835.7	93.0	7858.3	1.124
	ζ_{5d}	561.2	(fixed)	535.4	1.048
	F^2(5p, 5d)	37369.4	429.0	42222.1	0.885
	$G^{1(}$ 5p, 5d)	38543.1	195.0	48658.0	0.792
	$G^{3(}$ 5p, 5d)	22984.4	466.0	30892.8	0.744
$5p^2\,6s$	E_{av} $(5p^2\,6s)$	394273.5	97.0	392662.6	1.004
	F^2(5p, 5p)	44224.2	562.0	54144.0	0.817
	α_{5p}	100.2	57.0		
	ζ_{5p}	8124.4	(fixed)	8124.1	1.000
	G^1(5p, 6s)	5386.4	287.0	6709.8	0.803
4f 5s 5p	E_{av} (4f 5s 5p)	288889.7	(fixed)	288895.0	1.000
	ζ_{4f}	99.1	(fixed)	99.1	1.000
	ζ_{5p}	7579.0	(fixed)	7579.1	1.000
	F^2(4f, 5p)	38879.0	(fixed)	45740.1	0.850
	G^3(4f, 5s)	25301.1	(fixed)	33734.8	0.750
	G^2(4f, 5p)	28393.5	(fixed)	37858.0	0.750
	G^4(4f, 5p)	19911.7	(fixed)	26549.0	0.750
	G^1(5s, 5p)	51615.0	(fixed)	68820.0	0.750
$5s^2\,5g$	E_{av} $(5s^2\,5g)$	297965.9	219.0	307484.5	0.968
	ζ_{5g}	1.0	(fixed)	1.0	1.000

$5s^2\ 6g$	$E_{av}\ (5s^2\ 6g)$	332208.2	172.0	341920.1	0.971
	ζ_{5g}	0.6	(fixed)	0.6	1.000
$5s^2\ 7g$	$E_{av}\ (5s^2\ 7g)$	362560.8	(fixed)	362561.7	1.000
	ζ_{7g}	0.3	(fixed)	0.3	1.000
$5s\ 5p^2\ -5s^2\ 5d$	R^1(5p, 5p; 5s, 5d)	33746.1	1687.0	54793.0	0.616
$5s\ 5p^2\ -5s^2\ 6d$	R^1(5p, 5p; 5s, 6d)	14387.3	719.0	23360.3	0.616
$5s\ 5p^2\ -5s^2\ 7d$	R^1(5p, 5p; 5s, 7d)	8801.4	440.0	14290.8	0.616
$5s\ 5p^2\ -5s^2\ 6s$	R^1(5p, 5p; 5s, 6s)	-961.3	-48.0	-1560.8	0.616
$5s\ 5p^2\ -5s^2\ 7s$	R^1(5p, 5p; 5s, 7s)	-1142.3	-57.0	-1854.8	0.616
$5s\ 5p^2\ -5s^2\ 8s$	R^1(5p, 5p; 5s, 8s)	-963.6	-48.0	-1564.6	0.616
$5s\ 5p^2\ -5s^2\ 9s$	R^1(5p, 5p; 5s, 9s)	-965.9	(fixed)	-1287.8	0.750
$5s\ 5p^2\ -5p^2\ 5d$	R^1(5s, 5p; 5p, 5d)	34716.2	1736.0	56368.3	0.616
	R^2(5s, 5p; 5d, 5p)	25081.8	1254.0	40725.0	0.616
$5s\ 5p^2\ -5p^2\ 6s$	R^1(5s, 5p; 5p, 6s)	213.7	11.0	346.9	0.616
	R^0(5s, 5p; 6s, 5p)	89.2	4.0	145.0	0.616
$5s\ 5p^2\ -4f\ 5s\ 5p$	R^2(5p, 5p; 4f, 5p)	-32507.3	(fixed)	-43343.0	0.750
$5s^2\ 5d\ -5p^2\ 5d$	R^1(5s, 5s; 5p, 5p)	43035.3	2152.0	69875.9	0.616
$5s^2\ 5d\ -4f\ 5s\ 5p$	R^3(5s, 5d; 4f, 5p)	-21057.4	(fixed)	-28076.5	0.750
	R^1(5s, 5d; 5p, 4f)	-31560.6	(fixed)	-42080.7	0.750
$5s^2\ 6d\ -4f\ 5s\ 5p$	R^1(5s, 6d; 5p, 4f)	-9705.9	(fixed)	-12941.2	0.750
	R^3(5s, 7d; 4f, 5p)	-9979.1	(fixed)	-13305.5	0.750
$5s^2\ 6s\ -5p^2\ 6s$	R^1(5s, 5s; 5p, 5p)	-6037.3	(fixed)	-8049.8	0.750
	R^2(5p, 5d; 5p, 6s)	-5875.5	(fixed)	-7834.1	0.750
$5p^2\ 5d\ -5p^2\ 6s$	R^1(5p, 5d; 6s, 5p)	43441.0	2172.0	70534.4	0.616
$4f\ 5s\ 5p\ -5s^2\ 5g$	R^1(4f, 5p; 5g, 5s)	-7279.5	-364.0	-11819.5	0.616
	R^3(4f, 5p; 5s, 6g)	-2434.1	-122.0	-3952.1	0.616
$4f\ 5s\ 5p\ -5s^2\ 6g$	R^1(4f, 5p; 6g, 5s)	-25071.8	(fixed)	-33429.1	0.750
	R^3(4f, 5p; 5s, 7g)	-32422.0	(fixed)	-43229.4	0.750
$4f\ 5s\ 5p\ -5s^2\ 7g$	R^1(4f, 5p; 7g, 5s)	-4734.8	-237.0	-7687.8	0.616
	σ	204			

CHAPTER - 6

The sixth Spectrum of iodine: I VI

6.1. Introduction:

The spectrum of five-times ionized iodine is Cd I like with a closed shell as its ground configuration $5s^2$, gives only $^1S_0$ level. Its excitation leads to two-electron system thus comprises of singlets and triplets level structure. Bloch *et al.*[1] published a line list of iodine with tentative ionization assignments to each lines in the wavelength region 190- 1010 Å Krishnamurty and Fernando [2] used the line list of Bloch *et al.* and classified seventeen lines as I VI transitions. Even-Zohar and Fraenkel [3] classified ten lines of this spectrum in the wavelength region 290 - 610Å. O'Neill *et al.* [4] made correct assignments of another five lines of I VI in the wavelength region 600 - 1121Å using beam-foil spectrum with an accuracy of ± 1 Å. Kaufman, Sugar and Joshi [5] revised and extended the earlier work of Krishnamurty and Fernando [2] and Even-Zohar and fraenkel [3]. They established the levels of $5s^2$, 5sns(n = 6, 7), 5snp(n = 5, 6), 5s5d and $5p^2$ configurations and two levels of core excited configuration $4d^95s^25p$ and one level of $4d^95s^24f$. They established 23 levels based on the identification of 38 lines in the wavelength region 139 - 1480Å. Tauheed, Joshi and Pinnington [6] revised and extended the spectrum of I VI. They added two new configurations 5p5d and 5p6s and reported the missing level of $5p^2$ $^1S_0$ revising 5s5d $^1D_2$ and 5s6s $^1S_0$. They classified 66 new lines.

6.2. The Term Structure of I VI:

Ground configuration:

$5s^2$: $^1S_0$

Excited configurations:

5snp : $^3P_{0,1,2}$; $^1P_1$

5snd : $^3D_{1,2,3}$; $^1D_2$

5snf : $^3F_{2,3,4}$; $^1F_3$

5sng : $^3G_{3,4,5}$; $^1G_4$

5sns : $^3S_1$; $^1S_0$

$5p^2$: $^3P_{0,1,2}$; $^1D_2$, $^1S_0$

5p5d : $^3F_{2,3,4}$; $^3D_{1,2,3}$; $^3P_{0,1,2}$; $^1F_3$; $^1D_2$; $^1P_1$

5p6s : $^3P_{0,1,2}$; $^1P_1$

$5d^2$: $^3F_{2,3,4}$; $^3P_{0,1,2}$; $^1G_4$; $^1D_2$; $^1S_0$

$6s^2$: $^1S_0$

5p6p : $^3D_{1,2,3}$; $^3P_{0,1,2}$; $^3S_1$; $^1D_2$; $^1P_1$; $^1S_0$

5p4f : $^3G_{3,4,5}$; $^3F_{2,3,4}$; $^3D_{1,2,3}$ $^1G_4$; $^1F_3$; $^1D_2$

5d4f : $^3H_{4,5,6}$; $^3G_{3,4,5}$; $^3F_{2,3,4}$; $^3D_{1,2,3}$; $^1H_5$; $^1G_4$; $^1F_3$; $^1D_2$

$4d^95s^25p$: $^3F_{4,3,2}$; $^3D_{3,2,1}$; $^3P_{2,1,0}$; $^1F_3$; $^1D_2$; $^1P_1$

$4d^95s^24f$: $^3H_{6,5,4}$; $^3G_{5,4,3}$; $^3F_{4,3,2}$; $^3D_{3,2,1}$; $^1H_5$; $^1G_4$; $^1F_3$; $^1D_2$

$4d^95s^25d$: $^3G_{5,4,3}$; $^3F_{4,3,2}$; $^3D_{3,2,1}$; $^3P_{2,1,0}$; $^3S_1$; $^1G_4$; $^1F_3$; $^1D_2$; $^1P_1$; $^1S_0$

$4d^95s^26s$: $^3D_{3,2,1}$; $^1D_2$

6.3. Analysis and discussion:

Extensive use was made of the matrix calculations programs of Cowan [7] to predict energy levels, wavelengths and intensities. In order to *include the configuration interaction effect the configurations $5s^2$, 5s6s,* 5s7s, 5s8s, 5s5d, 5s6d, 5s7d, 5s5g, 5s6g, 5s7g, $5p^2$, $5d^2$, $6s^2$, 5p6p, 5p4f, $4d^95s^25d$, $4d^95s^26s$ and $4d^95s^25g$ were incorporated for even parity configurations and 5s5p, 5s6p, 5s7p, 5s4f, 5s5f, 5s6f, 5p5d, 5p6d, 5d4f, 5p6s and $4d^95s^24f$ were considered for odd parity system. Least squares fitted programs were run to obtain the scaling factor for reported levels. This scaling was used for extended work. The existing analysis of I VI was checked very carefully. All the levels reported by Tauheed, Joshi and Pinnington [6] was found to be correct and are therefore confirmed in the present work. One of the missing level 5p5d $^1P_1$ in reference [6] has now been found at 386625 cm^{-1}. The new configurations studied are 5s8s, 5s6d, 5s5g, 5s6g, 5s7g, $5d^2$, 5p6p, $6s^2$, 5p4f, 5s7p, 5s4f, 5s5f, 5p5d completely and $4d^95s^2$(5d + 6s) partially. The two internally excited configurations $4d^95s^24f$ and $4d^95s^25p$ consist of 6 levels with J = 1 which can give radiative transition from ground level $^1S_0$. Only three out of six levels were known which have been used to locate 10 levels of $4d^95s^25d$ configuration. The attempt was made to identify the remaining three J = 1 levels of $4d^95s^2$ (5p + 4f) configurations but these transitions to the ground level lie in grazing incidence wavelength region. Our present spectral range does not cover the grazing incidence wavelength data. Therefore, these levels could not be established. However, one level of $4d^95s^25p$ could be identified through the transition from $4d^95s^25d$. These levels have been tried to fit in the least squares calculations keeping most of the parameters fixed at appropriate values, freeing E_{av} and linking G^k parameters to vary in the same ratio. The levels fitted reasonably with deviations between 71-270 cm^{-1} which may be considered a good fit. It would be appropriate to mention that 5s7s $^1S_0$ level has been taken by Tauheed *et al.* [6] from reference [3, 8]. However in the present work we could not see the line at

343.308 Å on any of our list rather we saw a line at 343.596 Å present on all our line list and this has been used to establish 5s7s $^1S_0$ level at 418462 cm^{-1} this changes the earlier level by 245 cm^{-1}.

It should be pointed out that the *ab initio* calculations predict very little splitting of ^3G term for 5s5g, 5s6g and 5s7g configurations. We observed no splitting of $^3G_3$ and $^3G_4$ levels in 5s5g and 5s6g configurations. However, $^3G_5$ level is found 7cm^{-1} above the $^3G_3$ and $^3G_4$ levels in both 5s5g and 5s6g configurations. No further splitting of ^3G levels was observed in 5s7g configuration. However, $^1G_4$ was well separated in 5s5g and 5s6g and was found normal but 5s7g $^1G_4$ showed strong interaction with $5d^2$ $^1G_4$ and was observed below 5s7g ^3G levels with its LS purity 62 %.

All the observed levels of both parities were used for least squares fitted parametric calculations. The parameter scaling looks very satisfactory. The standard deviations for even and odd parity configurations were found to be 230 cm^{-1} and 133 cm^{-1} respectively. **One hundred twenty nine** levels have been established based on the identification of **two hundred sixty five** lines in this spectrum. The classified lines are listed in Table 6.1. Least squares fitted levels along with their LS percentage compositions for even and odd parity configurations are given in Table 6.2 and 6.3 and the corresponding least squares fitted Slater energy parameters are given in Table 6.4 and 6.5 respectively. The position of various configurations and their energy spread for even and odd parities are shown in Fig. 6.1 and Fig.6.2.

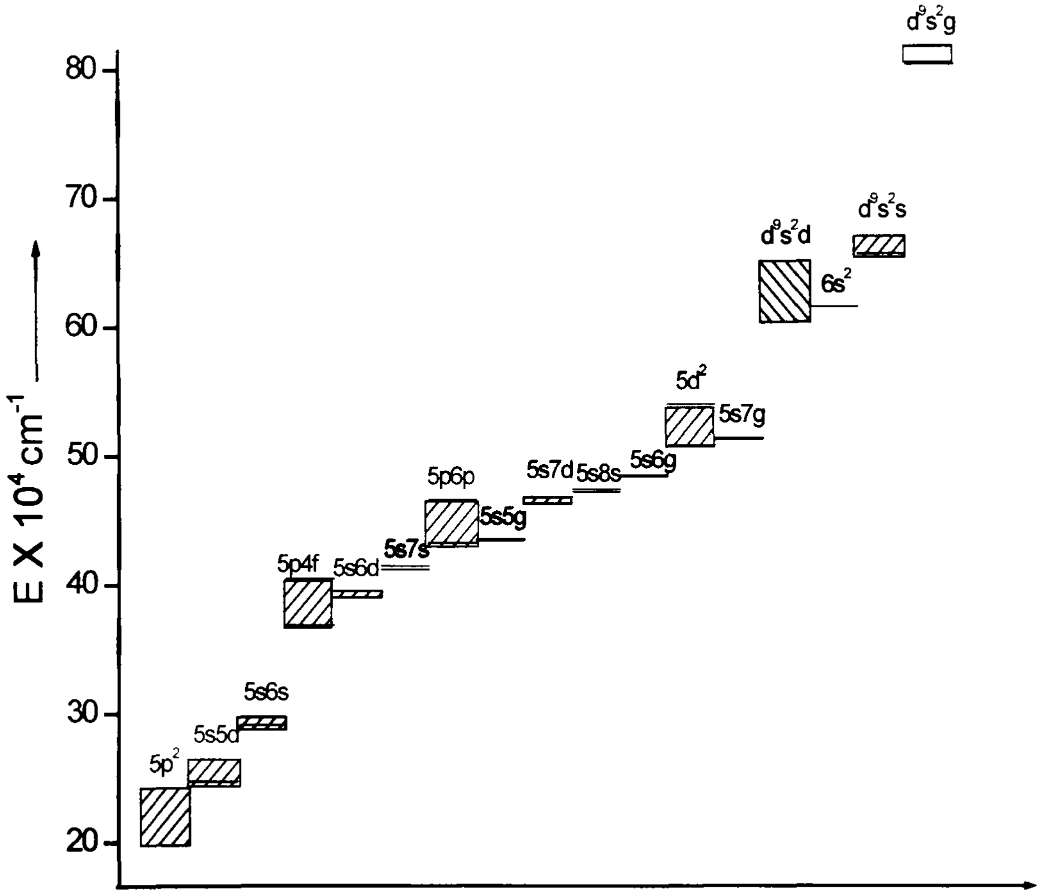


Fig. 6.1. Energy spread of various configurations in even parity system of I VI, unfilled block represents not studied configuration.

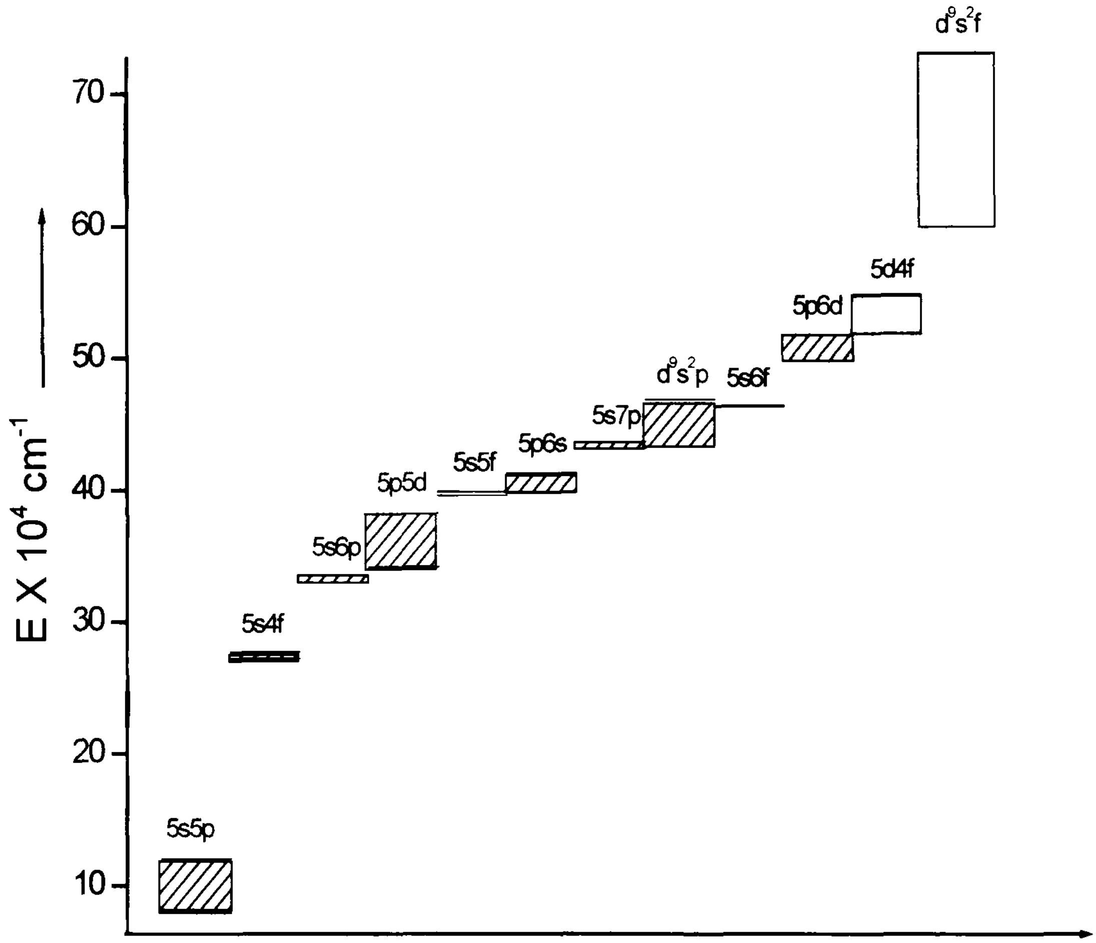


Fig. 6.2 Energy spread of various configurations in odd parity system of I VI, unfilled blocks represent not studied configurations.

6.4. Ionization Potential:

Kaufman, Sugar and Joshi [5] used 5s5p and 5s6p two member series to estimate the ionization potential of I VI at 599800 ± 3000 cm^{-1}. In the present investigation we have at least three different series 5sns (n = 6-8) 5snp (n = 5-7) and 5sng (n = 5-7) with three members known. Edlén's polarization formula [9] has been used to calculate the series limits. The 5sns series gives the value of ionization potential at 600478 cm^{-1}, the 5snp series gives at 600537 cm^{-1} and 5sng series calculates the series limit at 599171 cm^{-1}. We adapted the mean value 600010 ± 1000 cm^{-1} or 74.39 ± 0.12 eV.

References:

1. L. Bloch, E. Bloch and N. Felici, "Recherches sur les spectres d' étincelle de l'iode dansl'ultraviolet extrem," J. Phys. Rad. **8**, 355 (1937).
2. Krishnamurthy, S. G. and Fernando, I., Ind. J. Phys. **23**, 172 (1949).
3. M. Even-Zohar and B. S. Fraenkel, " A study of EUV spectra in the fifth period," J. Phys. **B 5** 1596 (1972).
4. J.A. O' Niell, E.H. Pinnington, K. E. Donnelly, and R.L. Brooks, " A study of the beam foil spectrum of iodine from 400 to 1300Å," Phys Scr. **20**, 60 (1979).
5. Kaufman, V., Sugar, J. and Joshi, Y.N., J. opt. Soc. Am. **B 3**, 619 (1988).
6. A. Tauheed, Y.N. Joshi and E.H. Pinnington, Physica Scripta. **56**, 289 (1997).
7. R. D. Cowan, The Theory of Atomic Structure and Spectra (University of California Press, Berkeley, 1981); Cowan Code of computer programs suited for VAX-type computers provided by Dr. Cowan to authors' research group.
8. Ansbacher, W., Pinnington, E.H.,Tuheed, A. and Kernahan, J.A., J. Phys. **B 24**, 587 (1991).
9. B. Edlén "Atomic Spectra" in Handbuch der Physik Springer Verlag, Vol. **27**, 80-220 (1964).

Table 6.1. Classified lines of I VI Spectrum

Wavelength λ (Å)	Wavenumber ν (cm^{-1})	Int	Ch[a]	Classification[b]	Diff.[c] Δ λ(Å)
139.547*	716604.4	20		$5s^2\ ^1S_0$ - $d^9s^2f\,^1P_1$	0.000
217.093*	460632.1	25		$5s^2\ ^1S_0$ - $d^9s^2p\,^3D_1$	0.000
220.663*	453179.7	50		$5s^2\ ^1S_0$ - $d^9s^2p\,^1P_1$	0.000
292.635*	341722.6	50		$5s^2\ ^1S_0$ - $5s6p\ ^1P_1$	0.000
302.241*	330862.0			$5s5p\ ^3P_0$ - $5s7s\ ^3S_1$	0.003
305.571*	327256.0			$5s5p\ ^3P_1$ - $5s7s\ ^3S_1$	0.012
315.611	316845.4	15		$5s5p\ ^3P_2$ - $5s7s\ ^3S_1$	0.000
336.060	297566.3	10		$5p^2\ ^3P_2$ - $5p6d\ ^3P_1$	-0.005
343.596	291039.1	20		$5s5p\ ^1P_1$ - $5s7s\ ^1S_0$	0.000
467.243	214021.2	10		$d^9s^2p\,^1P_1$ - $d^9s^2s\,^3D_2$	0.000
468.174	213596.0	45		$5s5p\ ^3P_1$ - $5s6s\ ^1S_0$	0.001
468.729	213343.1	10		$d^9s^2p\,^1P_1$ - $d^9s^2s\,^3D_1$	0.002
473.641	211130.5	10		$5p^2\ ^3P_1$ - $5p6s\ ^1P_1$	-0.004
474.857	210589.7	8		$5s5p\ ^3P_0$ - $5s6s\ ^3S_1$	-0.004
475.803	210171.1	55		$5p^2\ ^1D_2$ - $5p6s\ ^1P_1$	0.000
478.108	209157.8	12		$d^9s^2p\,^3P_1$ - $d^9s^2s\,^1D_2$	-0.001
479.460	208568.0	60		$5p^2\ ^3P_1$ - $5p6s\ ^3P_2$	-0.003
481.589	207645.9	20		$5p6s\ ^3P_1$ - $6s^2\ ^1S_0$	0.001
481.683	207605.4	62		$5p^2\ ^1D_2$ - $5p6s\ ^3P_2$	0.009
483.112	206991.3	10		$5s5p\ ^3P_1$ - $5s6s\ ^3S_1$	0.001
485.689	205892.9	25		$d^9s^2p\,^3D_1$ - $d^9s^2s\,^3D_1$	-0.002
490.075	204050.3	60		$5p^2\ ^3P_0$ - $5p6s\ ^3P_1$	0.002
500.066	199973.6	5		$d^9s^2p\,^1P_1$ - $d^9s^2s\,^1D_2$	0.001
506.021	197620.2	60		$5p^2\ ^3P_2$ - $5p6s\ ^1P_1$	-0.003
508.732	196567.2	8		$5s5p\ ^3P_2$ - $5s6s\ ^3S_1$	0.002
511.090	195660.3	35		$5p^2\ ^3P_1$ - $5p6s\ ^3P_1$	0.003
512.676	195055.0	60		$5p^2\ ^3P_2$ - $5p6s\ ^3P_2$	0.006

513.603	194703.0	60		$5p^2\ ^1D_2$ - $5p6s\ ^3P_1$	0.003
514.648	194307.7	50		$5p^2\ ^3P_1$ - $5p6s\ ^3P_0$	0.007
520.346	192179.9	40		$5p6s\ ^1P_1$ - $6s^2\ ^1S_0$	-0.001
541.858	184550.2	18		$5s5d\ ^3D_3$ - $5s7p\ ^3P_2$	0.000
543.891	183860.3	10		$5s5d\ ^3D_1$ - $5s7p\ ^3P_0$	0.000
544.938	183507.1	7		$5s5d\ ^3D_2$ - $5s7p\ ^3P_1$	0.000
552.995	180833.5	60		$5s5p\ ^3P_1$ - $5s5d\ ^1D_2$	-0.002
560.090	178542.7	70	D	$5p^2\ ^1D_2$ - $5p5d\ ^1F_3$	0.002
				$d^9s^2p^3P_1$ - $d^9s^2d^3D_2$	0.003
570.014	175434.4	65		$5s5p\ ^1P_1$ - $5s6s\ ^1S_0$	-0.001
574.887	173947.3	50	D	$5p^2\ ^1S_0$ - $5p6s\ ^1P_1$	-0.010
				$d^9s^2p^3P_1$ - $d^9s^2d^3P_1$	0.000
586.320	170555.2	35		$d^9s^2p^1P_1$ - $d^9s^2d^3F_2$	-0.014
586.827	170408.1	15		$5s5p\ ^3P_2$ - $5s5d\ ^1D_2$	0.004
587.806	170124.2	15		$5s5d\ ^1D_2$ - $5s7p\ ^1P_1$	0.000
590.466	169357.9	5		$d^9s^2p^1P_1$ - $d^9s^2d^3D_2$	0.007
591.492	169063.9	60		$d^9s^2p^3P_1$ - $d^9s^2d^3P_0$	0.000
597.792	167282.3	30		$d^9s^2p^1P_1$ - $d^9s^2d^3D_1$	0.000
600.025	166659.8	70		$d^9s^2p^3P_1$ - $d^9s^2d^1D_2$	-0.002
601.858	166152.1	50		$5s5p\ ^3P_0$ - $5s5d\ ^3D_1$	-0.003
602.435	165993.0	60		$5p^2\ ^3P_2$ - $5p5d\ ^1F_3$	-0.007
606.047	165003.6	55		$5p^2\ ^3P_1$ - $5p5d\ ^3P_2$	-0.008
606.931	164763.5	25		$d^9s^2p^1P_1$ - $d^9s^2d^3P_1$	0.000
607.311	164660.3	55		$5p^2\ ^3P_1$ - $5p5d\ ^3P_1$	-0.014
607.480	164614.5	40		$5p5d\ ^3F_3$ - $5d^2\ ^1G_4$	0.014
607.773	164535.1	50		$5p^2\ ^3P_1$ - $5p5d\ ^3P_0$	-0.002
609.590	164044.7	50		$5p^2\ ^1D_2$ - $5p5d\ ^3P_2$	-0.001
610.856	163704.6	40		$5p^2\ ^1D_2$ - $5p5d\ ^3P_1$	-0.020
612.447	163279.4	100		$5s5p\ ^3P_1$ - $5s5d\ ^3D_2$	-0.003
613.137	163095.8	30		$d^9s^2p^3D_1$ - $d^9s^2d^3F_2$	0.013
615.176	162555.1	50		$5s5p\ ^3P_1$ - $5s5d\ ^3D_1$	0.000
616.291	162261.1	50	B	$5p^2\ ^1D_2$ - $5p5d\ ^3D_3$	0.008
616.945	162089.0	40		$d^9s^2p^3P_1$ - $d^9s^2d^1P_1$	0.000

617.626	161910.3	25	$d^9s^2p\,^3D_1$ - $d^9s^2d\,^3D_2$	-0.009
618.437	161698.0	50	$5p^2\ ^3P_0$ - $5p5d\ ^3D_1$	-0.011
629.184	158936.0	35	$5p5d\ ^1D_2$ - $5d^2\ ^3P_1$	0.004
631.012	158475.6	25	$5p^2\ ^1S_0$ - $5p6s\ ^3P_1$	0.007
632.490	158105.2	60	$5p^2\ ^3P_1$ - $5p5d\ ^3D_2$	-0.007
633.199	157928.2	30	$5p5d\ ^1D_2$ - $5d^2\ ^1D_2$	0.006
635.021	157475.2	10	$d^9s^2p\,^1P_1$ - $d^9s^2d\,^1D_2$	0.002
636.347	157147.0	30	$5p^2\ ^1D_2$ - $5p5d\ ^3D_2$	-0.003
638.530	156609.6	20	$5s4f\ ^3F_2$ - $5s5g\ ^3G_3$	-0.004
638.951	156506.6	45	$5s4f\ ^3F_3$ - $5s5g\ ^3G_4$	0.003
639.394	156398.1	13	$5s5p\ ^3P_1$ - $5p^2\ ^1S_0$	-0.005
639.498	156372.7	15	$d^9s^2p\,^3P_1$ - $d^9s^2d\,^3S_1$	0.000
639.809	156296.7	75	$5s4f\ ^3F_4$ - $5s5g\ ^3G_5$	0.000
649.072	154066.1	200	$5s5p\ ^3P_2$ - $5s5d\ ^3D_3$	0.001
652.280	153308.3	30	$5p^2\ ^3P_1$ - $5p5d\ ^3D_1$	-0.012
653.692	152977.3	30	$5p5d\ ^3D_1$ - $5d^2\ ^3P_0$	-0.011
653.815	152948.5	35	$5p5d\ ^3D_1$ - $5d^2\ ^1D_2$	-0.008
654.006	152903.9	35	$d^9s^2p\,^1P_1$ - $d^9s^2d\,^1P_1$	0.006
654.103	152881.1	10	$d^9s^2p\,^1P_1$ - $d^9s^2d\,^3P_2$	0.000
654.214	152855.2	100	$5s5p\ ^3P_2$ - $5s5d\ ^3D_2$	-0.001
656.877	152235.4	60	$5s4f\ ^1F_3$ - $5s5g\ ^1G_4$	0.000
657.329	152130.8	10	$5s5p\ ^3P_2$ - $5s5d\ ^3D_1$	0.003
658.015	151972.2	25	$5p5d\ ^3F_3$ - $5d^2\ ^3F_3$	0.009
660.093	151493.7	65	$5p^2\ ^3P_2$ - $5p5d\ ^3P_2$	-0.007
661.595	151149.8	45	$5p^2\ ^3P_2$ - $5p5d\ ^3P_1$	-0.011
663.142	150797.3	10	$5p5d\ ^3F_3$ - $5d^2\ ^3F_2$	0.003
664.927	150392.5	25	$5p4f\ ^3G_3$ - $5p6d\ ^1F_3$	-0.006
667.948	149712.2	70	$5p^2\ ^3P_2$ - $5p5d\ ^3D_3$	-0.004
670.423	149159.6	75	$5p5d\ ^1P_1$ - $5d^2\ ^1S_0$	0.000
671.718	148872.0	20	$5s5d\ ^3D_2$ - $5s5f\ ^1F_3$	0.006
671.922	148826.9	20	$5p5d\ ^1D_2$ - $5d^2\ ^3F_3$	0.011

674.191	148325.9	65		$5p^2\ ^3P_1 - 5p5d\ ^1D_2$	-0.015
678.427	147399.7	85		$5s5d\ ^3D_1 - 5s5f\ ^3F_2$	-0.003
678.574	147367.9	65		$5p^2\ ^1D_2 - 5p5d\ ^1D_2$	-0.012
681.203	146799.2	85		$5s5d\ ^3D_2 - 5s5f\ ^3F_3$	-0.002
681.778	146675.4	65		$5s5d\ ^3D_2 - 5s5f\ ^3F_2$	0.001
686.052	145761.5	65		$5s5d\ ^3D_3 - 5s5f\ ^3F_4$	-0.001
686.875	145586.9	65		$5s5d\ ^3D_3 - 5s5f\ ^3F_3$	0.002
687.501	145454.4	20		$d^9s^2p^3D_1 - d^9s^2d^1P_1$	-0.005
693.380	144221.1	42		$5p^2\ ^1D_2 - 5p5d\ ^3F_3$	-0.004
696.218	143633.1	35	B	$5p5d\ ^3P_2 - 5d^2\ ^3P_2$	0.020
700.660	142722.6	60		$5p5d\ ^3P_0 - 5d^2\ ^3P_1$	0.012
700.916	142670.4	65	D	$5s5p\ ^1P_1 - 5s5d\ ^1D_2$	0.002
				$5p5d\ ^3D_1 - 5d^2\ ^3F_2$	-0.002
701.233	142605.9	15		$5p5d\ ^3P_1 - 5d^2\ ^3P_1$	-0.015
706.106	141621.8	45		$5p5d\ ^3P_1 - 5d^2\ ^3P_0$	0.010
706.239	141595.2	20		$5p5d\ ^3P_1 - 5d^2\ ^1D_2$	0.002
709.385	140967.2	35		$5p^2\ ^1S_0 - 5p5d\ ^1P_1$	0.000
711.764	140496.0	25		$5s6p\ ^3P_1 - 5s8s\ ^3S_1$	0.001
719.171	139048.9	15		$5p5d\ ^3D_2 - 5d^2\ ^3F_3$	-0.003
724.422	138041.0	62		$5p^2\ ^1D_2 - 5p5d\ ^3F_2$	-0.004
734.046	136231.2	30		$5s6p\ ^3P_2 - 5s8s\ ^3S_1$	-0.001
734.211	136200.6	10		$5s6p\ ^1P_1 - 5s8s\ ^1S_0$	0.000
741.384	134882.8	55		$5p5d\ ^3D_3 - 5d^2\ ^3F_4$	0.000
741.769	134812.8	45		$5p^2\ ^3P_2 - 5p5d\ ^1D_2$	0.002
746.639	133933.5	20		$5p5d\ ^3D_3 - 5d^2\ ^3F_3$	-0.012
753.457	132721.6	5		$5s5p\ ^3P_1 - 5p^2\ ^3P_2$	0.003
758.771	131792.1	15		$5p4f\ ^3D_3 - 5p6d\ ^1F_3$	0.004
759.463	131672.0	65	B	$5p^2\ ^3P_2 - 5p5d\ ^3F_3$	-0.022
761.500	131319.7	25		$5s5d\ ^1D_2 - 5s5f\ ^1F_3$	-0.005
766.341	130490.2	25		$5p5d\ ^1P_1 - 5d^2\ ^3P_2$	-0.016
767.480	130296.6	15		$5p5d\ ^1F_3 - 5d^2\ ^1G_4$	-0.008
775.946	128874.9	25		$5p4f\ ^3D_3 - 5p6d\ ^3F_4$	0.010
781.940	127887.0	15		$5p4f\ ^1D_2 - 5p6d\ ^1P_1$	0.002

788.590	126808.6	40		5s6p $^1P_1$ - 5p6p $^1S_0$	0.042
796.886	125488.4	26		$5p^2$ $^3P_2$ - 5p5d $^3F_2$	-0.001
797.670	125365.2	15		5s4f $^1F_3$ - 5s6d $^1D_2$	0.004
804.569	124290.1	20		5s4f $^3F_4$ - 5s6d $^3D_3$	-0.007
806.571	123981.7	35		5s4f $^3F_3$ - 5s6d $^3D_2$	0.000
807.533	123833.9	25		5s4f $^3F_2$ - 5s6d $^3D_1$	-0.007
810.728	123346.0	45		5s6s $^3S_1$ - 5p6s $^1P_1$	0.024
814.278	122808.2	250		5s5p $^3P_0$ - $5p^2$ $^3P_1$	0.005
817.676	122297.8	150		5s5p $^3P_2$ - $5p^2$ $^3P_2$	0.004
819.035	122094.9	5		5s6d $^3D_1$ - 5p6d $^1P_1$	-0.008
821.972	121658.7	35		5s5d $^3D_1$ - 5p5d $^3P_2$	0.003
824.317	121312.5	50		5s5d $^3D_1$ - 5p5d $^3P_1$	0.011
825.140	121191.5	25		5s5d $^3D_1$ - 5p5d $^3P_0$	0.004
827.895	120788.2	45		5s6s $^3S_1$ - 5p6s $^3P_2$	-0.004
829.273	120587.5	35		5s5d $^3D_2$ - 5p5d $^3P_1$	0.022
831.876	120210.2	10		5s6d $^3D_1$ - 5p6d $^3P_0$	-0.003
832.147	120171.1	250		5s5p $^3P_1$ - $5p^2$ $^1D_2$	-0.008
835.777	119649.1	35		5s6p $^3P_0$ - 5p6p $^3S_1$	-0.014
838.843	119211.8	300		5s5p $^3P_1$ - $5p^2$ $^3P_1$	0.007
839.246	119154.6	40		5s5d $^3D_2$ - 5p5d $^3D_3$	0.001
839.672	119094.1	15		5s6d $^3D_1$ - 5p6d $^3P_1$	-0.017
841.017	118903.7	40	B	5s6d $^3D_2$ - 5p6d $^3P_2$	-0.016
844.769	118375.6	20		5s6d $^3D_3$ - 5p6d $^3P_2$	-0.001
845.779	118234.2	65		5s5p $^1P_1$ - $5p^2$ $^1S_0$	0.004
847.856	117944.6	45	B	5s5d $^3D_3$ - 5p5d $^3D_3$	-0.010
847.909	117937.2	30		5s4f $^3F_3$ - 5p4f $^1D_2$	0.005
848.320	117880.0	60		5s5d $^1D_2$ - 5p5d $^1F_3$	0.002
854.826	116982.9	30		5s6d $^3D_2$ - 5p6d $^3D_3$	0.014
855.709	116862.2	15		5s4f $^3F_3$ - 5p4f $^1G_4$	-0.005
856.198	116795.4	35	B	5s6d $^3D_1$ - 5p6d $^1D_2$	-0.013
856.560	116746.0	45		5s6s $^1S_0$ - 5p6s $^1P_1$	-0.007
857.338	116640.1	45		5s4f $^3F_4$ - 5p4f $^1G_4$	0.022
858.070	116540.6	40		5s6d $^3D_2$ - 5p6d $^1D_2$	0.022

861.960	116014.6	30	5s6d $^3D_3$ - 5p6d $^1D_2$	0.023
862.790	115903.0	25	5s4f $^3F_2$ - 5p4f $^3D_1$	0.001
865.069	115597.7	30	5s6p $^1P_1$ - 5p6p $^1D_2$	0.004
865.953	115479.7	90	5s6p $^3P_1$ - 5p6p $^3P_2$	-0.008
870.158	114921.6	10	5s6p $^3P_2$ - 5p6p $^3S_1$	0.006
871.374	114761.3	30	5s5d $^3D_1$ - 5p5d $^3D_2$	-0.002
875.561	114212.5	15	5s5f $^3F_2$ - 5s7*g* $^3G_3$	0.009
875.948	114162.0	45	5s6p $^3P_0$ - 5p6p $^1P_1$	0.010
876.489	114091.6	10	5s5f $^3F_3$ - 5s7*g* $^3G_4$	-0.009
877.836	113916.5	15	5s5f $^3F_4$ - 5s7*g* $^3G_5$	0.000
879.088	113754.3	20	5s4f $^3F_2$ - 5p4f $^3D_2$	0.012
879.848	113656.0	80	5s4f $^3F_3$ - 5p4f $^3D_2$	-0.011
886.321	112825.9	60	5s5d $^3D_3$ - 5p5d $^3D_2$	0.002
887.416	112686.7	30	5s4f $^1F_3$ - 5p4f $^1D_2$	-0.002
888.920	112496.0	25	5s4f $^3F_3$ - 5p4f $^3D_3$	-0.001
890.068	112351.0	25	5s6p $^3P_2$ - 5p6p $^3D_3$	0.006
890.663	112275.9	25	5s4f $^3F_4$ - 5p4f $^3D_3$	0.012
895.963	111611.8	60	5s4f $^1F_3$ - 5p4f $^1G_4$	-0.013
902.339	110823.1	250	5s5p $^3P_1$ - 5p^2 $^3P_0$	0.000
909.391	109963.7	35	5s5d $^3D_1$ - 5p5d $^3D_1$	-0.005
911.191	109746.5	10	5s5p $^3P_2$ - 5p^2 $^1D_2$	-0.002
912.621	109574.5	15	5s5f $^1F_3$ - 5s7*g* $^1G_4$	0.000
915.428	109238.5	50	5s5d $^3D_2$ - 5p5d $^3D_1$	0.010
919.200	108790.2	70	5s5p $^3P_2$ - 5p^2 $^3P_1$	-0.009
919.555	108748.2	65	5s5d $^3D_3$ - 5p5d $^3F_4$	0.000
924.337	108185.7	30	5s4f $^3F_4$ - 5p4f $^3G_5$	0.001
926.563	107925.8	75	5s4f $^3F_3$ - 5p4f $^3F_4$	0.016
926.926	107883.5	40	5s6s $^3S_1$ - 5p6s $^3P_1$	-0.008
928.412	107710.8	15	5s4f $^3F_4$ - 5p4f $^3F_4$	-0.014
932.451	107244.2	10	5s4f $^1F_3$ - 5p4f $^3D_3$	0.002
938.686	106531.9	40	5s6s $^3S_1$ - 5p6s $^3P_0$	-0.003
939.996	106383.4	20	5s4f $^3F_2$ - 5p4f $^1F_3$	-0.002

940.894	106281.9	25		5s4f $^3F_3$ - 5p4f $^1F_3$	0.001
942.477	106103.4	25		5s6p $^3P_1$ - 5p6p $^3D_2$	-0.013
951.749	105069.7	30		5s6d $^3D_2$ - 5p6d $^3F_3$	-0.001
954.045	104816.9	30	B	5s6p $^3P_1$ - 5p6p $^3P_0$	0.020
956.569	104540.3	10		5s6d $^3D_3$ - 5p6d $^3F_3$	0.031
960.860	104073.4	25		5s6d $^3D_3$ - 5p6d $^3D_2$	-0.021
970.464	103043.5	50		5s5d $^3D_3$ - 5p5d $^1D_2$	0.016
971.990	102881.7	20		5s6d $^3D_2$ - 5p6d $^3F_2$	0.009
981.952	101838.0	20		5s6p $^3P_2$ - 5p6p $^3D_2$	-0.013
987.383	101277.8	25		5s6s $^1S_0$ - 5p6s $^3P_1$	0.002
989.017	101110.5	60		5s5d $^3D_2$ - 5p5d $^3F_3$	0.012
989.801	101030.4	55		5s4f $^1F_3$ - 5p4f $^1F_3$	0.002
1001.012	99898.9	55		5s5d $^3D_3$ - 5p5d $^3F_3$	0.013
1010.370	98973.6	25	B	5s6p $^3P_0$ - 5p6p $^3D_1$	-0.002
1015.092	98513.2	20		5s4f $^3F_2$ - 5p4f $^3F_2$	0.001
1023.043	97747.6	25		5s4f $^3F_3$ - 5p4f $^3G_4$	0.004
1025.330	97529.6	65		5s4f $^3F_4$ - 5p4f $^3G_4$	-0.002
1027.196	97352.4	20		5s4f $^3F_3$ - 5p4f $^3F_3$	0.005
1029.499	97134.6	15		5s4f $^3F_4$ - 5p4f $^3F_3$	-0.003
1045.425	95654.9	45		5s5d $^3D_1$ - 5p5d $^3F_2$	0.002
1053.400	94930.7	40		5s5d $^3D_2$ - 5p5d $^3F_2$	0.011
1053.984	94878.1	20		5p5d $^1D_2$ - 5p6p $^3P_2$	0.008
1054.576	94824.8	15		5p5d $^3F_2$ - 5p6p $^3D_2$	0.025
1057.523	94560.6	5		5s5p $^1P_1$ - 5p^2 $^3P_2$	-0.007
1064.982	93898.3	25		5s4f $^3F_3$ - 5p4f $^3G_3$	-0.008
1128.086	88645.7	15	D	5s5d $^3D_1$ - 5s6p $^3P_2$	-0.003
				5s4f $^1F_3$ - 5p4f $^3G_3$	0.007
1137.363	87922.7	20		5s5d $^3D_2$ - 5s6p $^3P_2$	-0.008
1146.320	87235.7	30		5p5d $^3F_2$ - 5p6p $^3D_1$	0.043
1153.262	86710.6	60		5s5d $^3D_3$ - 5s6p $^3P_2$	0.000
1169.513	85505.7	10		5p5d $^1D_2$ - 5p6p $^3D_2$	-0.049
1181.910	84608.8	15		5p5d $^1D_2$ - 5p6p $^3P_1$	0.004

1185.090	84381.8	70	5s5d $^3D_1$ - 5s6p $^3P_1$	-0.021
1187.775	84191.0	15	5p5d $^3P_1$ - 5p6p $^1D_2$	-0.017
1191.600	83920.8	50	5s5d $^3D_1$ - 5s6p $^3P_0$	-0.001
1195.374	83655.8	50	5s5d $^3D_2$ - 5s6p $^3P_1$	0.016
1196.776	83557.8	15	5s5d $^1D_2$ - 5p5d $^3F_3$	-0.007
1198.479	83439.1	18	5s5f $^3F_2$ - 5s6g $^3G_3$	-0.005
1200.153	83322.7	20	5p5d $^3D_2$ - 5p6p $^1P_1$	0.002
1200.261	83315.2	20	5s5f $^3F_3$ - 5s6g $^3G_4$	0.005
1202.669	83148.4	30	5s5f $^3F_4$ - 5s6g $^3G_5$	0.000
1215.776	82252.0	40	5p5d $^3P_1$ - 5p6p $^3S_1$	0.026
1219.404	82007.3	20	5s5p $^1P_1$ - 5p2 $^1D_2$	0.009
1220.801	81913.4	85	5p5d $^1P_1$ - 5p6p $^1S_0$	-0.018
1228.091	81427.2	25	5s5f $^1F_3$ - 5s6g $^1G_4$	0.000
1232.736	81120.4	25	5p5d $^3D_3$ - 5p6p $^3D_3$	-0.019
1250.264	79983.1	40	5p5d $^3D_3$ - 5p6p $^3P_2$	-0.036
1260.401	79339.8	18	5p5d $^3P_2$ - 5p6p $^3D_3$	-0.026
1262.037	79237.0	10	5p5d $^3D_1$ - 5p6p $^3P_0$	-0.011
1278.800	78198.3	25	5p5d $^3P_2$ - 5p6p $^3P_2$	0.024
1300.556	76890.2	80	5p5d $^3P_0$ - 5p6p $^1P_1$	0.028
1302.550	76772.5	5	5p5d $^3P_1$ - 5p6p $^1P_1$	-0.045
1336.389	74828.5	25	5p5d $^3D_2$ - 5p6p $^3P_1$	-0.008
1405.637	71142.1	60	5s6p $^3P_1$ - 5s6d $^1D_2$	0.004
1412.198	70811.6	20	5p6p $^3D_1$ - 5p6d $^3D_1$	-0.008
1413.174	70762.7	10	5p6p $^1P_1$ - 5p6d $^3P_0$	0.001
1435.862	69644.6	45	5p6p $^1P_1$ - 5p6d $^3P_1$	0.001
1442.086	69344.0	65	5p5d $^1F_3$ - 5p6p $^1D_2$	0.037
1451.927	68874.0	45	5p6p $^3D_1$ - 5p6d $^3F_2$	0.033
1473.407	67869.9	15	5p6p $^3P_2$ - 5p6d $^3P_1$	-0.003
1484.845	67347.1	30	5p6p $^1P_1$ - 5p6d $^1D_2$	-0.011
1488.922	67162.7	15	5p6p $^3S_1$ - 5p6d $^1P_1$	0.002
1514.851	66013.1	30	5p6p $^3P_2$ - 5p6d $^3D_3$	-0.003
1523.993	65617.1	30	5s6p $^1P_1$ - 5s6d $^1D_2$	-0.004
1531.846	65280.7	20	5p6p $^3D_3$ - 5p6d $^3F_4$	-0.003

1541.412	64875.6	15	5p6p $^3D_3$ - 5p6d $^3D_3$	-0.025
1545.249	64714.5	25	5s6p $^3P_0$ - 5s6d $^3D_1$	0.041
1550.231	64506.5	40	5s6p $^3P_1$ - 5s6d $^3D_2$	0.004
1556.210	64258.7	25	5s6p $^3P_1$ - 5s6d $^3D_1$	-0.050
1557.138	64220.4	30	5p6p $^3S_1$ - 5p6d $^3P_2$	0.005
1558.591	64160.5	25	5p6p $^3S_1$ - 5p6d $^3P_1$	0.007
1559.678	64115.8	40	5p6p $^3P_1$ - 5p6d $^3D_1$	0.007
1565.060	63895.3	10	5p6p $^3P_1$ - 5p6d $^3D_2$	-0.010
1575.426	63474.9	35	5p6p $^3D_2$ - 5p6d $^3F_3$	-0.011
1580.268	63280.4	50	d9s2d$^1S_0$ - d^9s^2f $^1P_1$	0.000
1587.271	63001.2	10	5p6p $^3D_2$ - 5p6d $^3D_2$	0.017
1631.625	61288.6	5	5p6p $^3D_2$ - 5p6d $^3F_2$	-0.030
1645.630	60767.0	35	5s6p $^3P_2$ - 5s6d $^3D_3$	0.011
1656.529	60367.2	5	5p6p $^1D_2$ - 5p6d $^3D_3$	0.020
1659.991	60241.3	70	5s6p $^3P_2$ - 5s6d $^3D_2$	0.005

a : Character of the line D – doubly classified line, B – blended line.

b : d^9s^2f stands for $4d^95s^24f$, d^9s^2p stands for $4d^95s^25p$, d^9s^2s for $4d^95s^26s$, and d^9s^2d for $4d^95s^25d$.

c : diff.($\Delta\lambda$) = observed λ – calculated λ from Table 6.2 & 6.3.

* : not observed in the present work, taken from ref. [5]

Table 6.2. Observed and fitted energy levels (in cm^{-1}) for even parity configurations of I VI spectrum

J	E(obs)	E(LSF)	diff.	LS-composition.
0	0.0	0.0	0.0	98% $4d^{10}$ $5s^2$
	200084.8	200060.0	24.8	91% $4d^{10}$ $5p^2$ ^3P + 8% $4d^{10}$ $5p^2$ ^1S
	245658.6	245667.0	-8.4	89% $4d^{10}$ $5p^2$ ^1S + 9% $4d^{10}$ $5p^2$ ^3P
	302858.0	302859.0	-1.0	99% $4d^{10}$ 5s 6s ^1S
	418462.9	418463.0	0.1	99% $4d^{10}$ 5s 7s ^1S
	441016.3	441177.0	-160.7	89% $4d^{10}$ 5p 6p ^3P + 10% $4d^{10}$ 5p 6p ^1S
	468538.0	468376.0	162.0	85% $4d^{10}$ 5p 6p ^1S + 10% $4d^{10}$ 5p 6p ^3P
	477923.2	477929.0	-5.8	96% $4d^{10}$ 5s 8s ^1S
	514755.0	514987.0	-232.0	99% $4d^{10}$ $5d^2$ ^3P
	535785.4	535753.0	32.4	97% $4d^{10}$ $5d^2$ ^1S
	611782.5	611783.0	-0.5	99% $4d^{10}$ $6s^2$
	613060.2	613150.0	-89.8	97% $4d^9$ 5s2 5d ^3P
	653323.6	653071.0	253.0	97% $4d^9$ 5s2 5d ^1S
1	208474.5	208528.0	-53.5	100% $4d^{10}$ $5p^2$ ^3P
	251816.9	251816.0	0.9	99% $4d^{10}$ 5s 5d ^3D
	296253.4	296252.0	4.0	99% $4d^{10}$ 5s 6s ^3S
	392524.0	392238.0	286.0	87% $4d^{10}$ 4f 5p ^3D + 12% $4d^{10}$ 5s 6d ^3D
	400453.8	400504.0	-50.4	86% $4d^{10}$ 5s 6d ^3D + 12% $4d^{10}$ 4f 5p ^3D
	416530.8	416530.0	0.8	100% $4d^{10}$ 5s 7s ^3S
	434711.0	434515.0	196.0	64% $4d^{10}$ 5p 6p ^3D + 32% $4d^{10}$ 5p 6p ^1P
	441406.1	441780.0	-373.9	39% $4d^{10}$ 5p 6p ^3P + 25% $4d^{10}$ 5p 6p ^1P
				+ 18% $4d^{10}$ 5p 6p ^3D + 17% $4d^{10}$ 5p 6p ^3S
	449900.8	449802.0	98.8	55% $4d^{10}$ 5p 6p ^3P + 30% $4d^{10}$ 5p 6p ^1P
				+ 14% $4d^{10}$ 5p 6p ^3D
	455384.7	455651.0	-266.3	79% $4d^{10}$ 5p 6p ^3S + 13% $4d^{10}$ 5p 6p ^1P
				+ 6% $4d^{10}$ 5p 6p ^3P
	-	463181.0	-	99% $4d^{10}$ 5s 7d ^3D
	476693.4	476693.0	0.4	100% $4d^{10}$ 5s 8s ^3S
	515733.9	515488.0	245.9	100% $4d^{10}$ $5d^2$ ^3P
	600369.0	600518.0	-149.0	77% $4d^9$ $5s^2$ 5d ^3S + 20% $4d^9$ $5s^2$ 5d ^3P
	606085.3	606482.0	-396.7	54% $4d^9$ $5s^2$ 5d ^1P + 25% $4d^9$ $5s^2$ 5d ^3D
				+ 20% $4d^9$ $5s^2$ 5d ^3P
	617943.6	617890.0	53.6	38% $4d^9$ $5s^2$ 5d ^1P + 36% $4d^9$ $5s^2$ 5d ^3P
				+ 19% $4d^9$ $5s^2$ 5d ^3S + 6% $4d^9$ $5s^2$ 5d ^3D

	620462.3	620575.0	-112.7	69% 4d^9 5s^2 5d ^{3}D + 24% 4d^9 5s^2 5d ^{3}P
				+ 6% 4d^9 5s^2 5d ^{1}P
	666524.1	666452.0	72.1	100% 4d^9 5s^2 6s ^{3}D
	-	801006.0	-	100% 4d^9 5s2 5g ^{3}D
2	209431.7	209419.0	12.7	57% 4d^{10} 5p^2 ^{1}D + 35% 4d^{10} 5p^2 ^{3}P
				+ 8% 4d^{10} 5s 5d ^{1}D
	221983.8	221955.0	28.8	65% 4d^{10} 5p^2 ^{3}P + 29% 4d^{10} 5p^2 ^{1}D
				+ 7% 4d^{10} 5s 5d ^{1}D
	252540.3	252545.0	-4.7	99% 4d^{10} 5s 5d ^{3}D
	270094.7	270095.0	-0.3	83% 4d^{10} 5s 5d ^{1}D + 13% 4d^{10} 5p^2 ^{1}D
	375134.2	375199.0	-64.8	82% 4d^{10} 4f 5p ^{3}F + 9% 4d^{10} 4f 5p ^{3}D
				+ 7% 4d^{10} 4f 5p ^{1}D
	390376.8	390296.0	80.8	65% 4d^{10} 4f 5p ^{3}D + 15% 4d^{10} 4f 5p ^{3}F
				+ 9% 4d^{10} 4f 5p ^{1}D + 6% 4d^{10} 5s 6d ^{3}D
	394660.0	394626.0	34.0	42% 4d^{10} 4f 5p ^{1}D + 37% 4d^{10} 5s 6d ^{1}D
				+ 16% 4d^{10} 4f 5p ^{3}D
	400703.8	400643.0	60.8	90% 4d^{10} 5s 6d ^{3}D + 7% 4d^{10} 4f 5p ^{3}D
	407339.5	407597.0	-257.5	54% 4d^{10} 5s 6d ^{1}D + 37% 4d^{10} 4f 5p ^{1}D
	442299.1	441946.0	353.1	77% 4d^{10} 5p 6p ^{3}D + 10% 4d^{10} 5p 6p ^{3}P
				+ 10% 4d^{10} 5p 6p ^{1}D
	451675.8	451788.0	-112.2	50% 4d^{10} 5p 6p ^{3}P + 23% 4d^{10} 5p 6p ^{1}D
				+ 20% 4d^{10} 5p 6p ^{3}D + 5% 4d^{10} 5s 7d ^{1}D
	457320.4	457146.0	174.4	38% 4d^{10} 5p 6p ^{1}D + 37% 4d^{10} 5p 6p ^{3}P
				+ 23% 4d^{10} 5s 7d ^{1}D
	-	463407.0	-	98% 4d^{10} 5s 7d ^{3}D
	-	468076.0	-	70% 4d^{10} 5s 7d ^{1}D + 26% 4d^{10} 5p 6p ^{1}D
	504449.9	504328.0	121.9	99% 4d^{10} 5d^2 ^{3}F
	514726.6	514943.0	-216.4	59% 4d^{10} 5d^2 ^{1}D + 39% 4d^{10} 5d2 ^{3}P
	517113.2	517002.0	111.2	61% 4d^{10} 5d^2 ^{3}P + 38% 4d^{10} 5d2 ^{1}D
	606061.1	606123.0	-61.9	59% 4d^9 5s^2 5d ^{3}P + 38% 4d^9 ^{5}s2 5d ^{3}D
	610655.6	610108.0	547.6	49% 4d^9 5s^2 5d ^{1}D + 19% 4d^9 ^{5}s2 5d ^{3}P
				+ 17% 4d^9 5s^2 5d ^{3}D + 15% 4d^9 ^{5}s2 5d ^{3}F
	622540.0	622703.0	-163.0	43% 4d^9 5s^2 5d ^{1}D + 36% 4d^9 ^{5}s2 5d ^{3}D
				+ 21% 4d^9 5s^2 5d ^{3}P
	623731.2	623610.0	121.2	82% 4d^9 5s^2 5d ^{3}F + 9% 4d^9 ^{5}s2 5d ^{3}D
				+ 8% 4d^9 5s^2 5d ^{1}D
	653153.8	653520.0	-366.2	56% 4d^9 5s^2 6s ^{1}D + 44% 4d^9 ^{5}s2 6s ^{3}D
	667201.2	666907.0	294.2	56% 4d^9 5s^2 6s ^{3}D + 44% 4d^9 ^{5}s2 6s ^{1}D
	-	801103.0	-	69% 4d^9 5s^2 5g ^{3}D + 30% 4d^9 ^{5}s2 5g ^{1}D
	-	801610.0	-	63% 4d^9 5s^2 5g ^{3}F + 31% 4d^9 ^{5}s2 5g ^{1}D
				+ 6% 4d^9 5s^2 5g ^{3}D

	-	814995.0	-	39% $4d^9\,5s^2$ 5g ^1D + 36% $4d^9\,^5s2$ 5g ^3F + 25% $4d^9\,5s^2$ 5g ^3D
3	253751.8	253750.0	1.8	99% $4d^{10}$ 5s 5d ^3D
	370619.7	370842.0	-222.3	59% $4d^{10}$ 4f 5p ^3G + 35% $4d^{10}$ 4f 5p ^1F
	374074.8	374015.0	59.8	47% $4d^{10}$ 4f 5p ^3F + 26% $4d^{10}$ 4f 5p ^1F + 20% $4d^{10}$ 4f 5p ^3D + 7% $4d^{10}$ 4f 5p ^3G
	383004.2	383042.0	-37.8	33% $4d^{10}$ 4f 5p ^3F + 32% $4d^{10}$ 4f 5p ^1F
	389217.9	389352.0	-134.1	73% $4d^{10}$ 4f 5p ^3D + 15% $4d^{10}$ 4f 5p ^3F + 7% $4d^{10}$ 4f 5p ^1F + 4% $4d^{10}$ 5s 6d ^3D
	401229.8	401152.0	77.8	95% $4d^{10}$ 5s 6d ^3D + 4% $4d^{10}$ 4f 5p ^3D
	433229.6	433199.0	30.6	99% $4d^{10}$ 5s 5g ^3G
	452814.2	452827.0	-12.8	94% $4d^{10}$ 5p 6p ^3D + 5% $4d^{10}$ 5s 7d ^3D
	-	463853.0	-	95% $4d^{10}$ 5s 7d ^3D + 5% $4d^{10}$ 5p 6p ^3D
	482654.7	482667.0	-12.3	100% $4d^{10}$ 5s 6g ^3G
	505626.3	505468.0	158.3	100% $4d^{10}$ $5d^2$ ^3F
	513429.6	513390.0	39.6	100% $4d^{10}$ 5s 7g ^3G
	-	608046.0	-	61% $4d^9\,5s^2$ 5d ^3D + 31% $4d^9$ $5s^2$ 5d ^3F + 6% $4d^9\,5s^2$ 5d ^3G
	-	609707.0	-	48% $4d^9$ $5s^2$ 5d ^1F + 24% $4d^9$ $5s^2$ 5d ^3D + 16% $4d^9$ $5s^2$ 5d ^3G + 12% $4d^9$ $5s^2$ 5d ^3F
	-	619118.0	-	78% $4d^9$ $5s^2$ 5d ^3G + 17% $4d^9$ $5s^2$ 5d ^1F + 5% $4d^9\,5s^2$ 5d ^3F
	-	624700.0	-	52% $4d^9$ $5s^2$ 5d ^3F + 33% $4d^9$ $5s^2$ 5d ^1F + 14% $4d^9\,5s^2$ 5d ^3D
	-	652889.0	-	100% $4d^9\,5s^2$ 6s ^3D
	-	801547.0	-	37% $4d^9\,5s^2$ 5g ^3F + 36% $4d^9$ $5s^2$ 5g ^3D + 27% $4d^9\,5s^2$ 5g ^1F
	-	801987.0	-	44% $4d^9\,5s^2$ 5g ^3G + 32% $4d^9$ $5s^2$ 5g ^1F + 24% $4d^9\,5s^2$ 5g ^3F
	-	814900.0	-	64% $4d^9\,5s^2$ 5g ^3D + 21% $4d^9$ $5s^2$ 5g ^3F + 16% $4d^9\,5s^2$ 5g ^1F
	-	815631.0	-	56% $4d^9\,5s^2$ 5g ^3G + 25% $4d^9$ $5s^2$ 5g ^1F + 19% $4d^9\,5s^2$ 5g ^3F
4	374469.0	374194.0	275.0	52% $4d^{10}$ 4f 5p ^3G + 37% $4d^{10}$ 4f 5p ^3F + 10% $4d^{10}$ 4f 5p ^1G
	384649.8	384495.0	154.8	59% $4d^{10}$ 4f 5p ^3F + 41% $4d^{10}$ 4f 5p ^3G
	393583.7	393751.0	-167.3	86% $4d^{10}$ 4f 5p ^1G + 6% $4d^{10}$ 4f 5p ^3G
	433229.6	433233.0	-3.4	99% $4d^{10}$ 5s 5g ^3G
	434209.0	434188.0	21.0	97% $4d^{10}$ 5s 5g ^1G
	482654.7	482674.0	-19.3	100% $4d^{10}$ 5s 6g ^3G

	482840.8	482786.0	54.5	98% $4d^{10}$ 5s 6g ^{1}G
	506577.8	506779.0	-201.2	98% $4d^{10}$ $5d^{2}$ ^{3}F
	510988.1	511234.0	-246.1	62% $4d^{10}$ 5s 7g ^{1}G + 36% $4d^{10}$ $5d^{2}$ ^{1}G
	513429.6	513393.0	36.6	100% $4d^{10}$ 5s 7g ^{3}G
	518270.2	518149.0	121.2	59% $4d^{10}$ $5d^{2}$ ^{1}G + 37% $4d^{10}$ 5s 7g ^{1}G
	-	605286.0	-	54% $4d^{9}$ $5s^{2}$ 5d ^{3}G + 44% $4d^{9}$ $5s^{2}$ 5d ^{1}G
	-	610831.0	-	79% $4d^{9}$ $5s^{2}$ 5d ^{3}F + 16% $4d^{9}$ $5s^{2}$ 5d ^{1}G
				+ 4% $4d^{9}$ $5s^{2}$ 5d ^{3}G
	-	621464.0	-	42% $4d^{9}$ $5s^{2}$ 5d ^{3}G + 40% $4d^{9}$ $5s^{2}$ 5d ^{1}G
				+ 19% $4d^{9}$ $5s^{2}$ 5d ^{3}F
	-	802000.0	-	56% $4d^{9}$ $5s^{2}$ 5g ^{3}F + 28% $4d^{9}$ $5s^{2}$ 5g ^{3}G
				+ 16% $4d^{9}$ $5s^{2}$ 5g ^{1}G
	-	802244.0	-	44% $4d^{9}$ $5s^{2}$ 5g ^{1}G + 29% $4d^{9}$ $5s^{2}$ 5g ^{3}G
				+ 28% $4d^{9}$ $5s^{2}$ 5g ^{3}H
	-	815649.0	-	44% $4d^{9}$ $5s^{2}$ 5g ^{3}F + 32% $4d^{9}$ $5s^{2}$ 5g ^{3}G
				+ 24% $4d^{9}$ $5s^{2}$ 5g ^{1}G
	-	815894.0	-	72% $4d^{9}$ $5s^{2}$ 5g ^{3}H + 17% $4d^{9}$ $5s^{2}$ 5g ^{1}G
				+ 11% $4d^{9}$ $5s^{2}$ 5g ^{3}G
5	385126.3	385248.0	-121.7	99% $4d^{10}$ 4f 5p ^{3}G
	433237.4	433281.0	-43.6	99% $4d^{10}$ 5s 5g ^{3}G
	482661.7	482683.0	-21.3	100% $4d^{10}$ 5s 6g ^{3}G
	513429.6	513397.0	32.6	100% $4d^{10}$ 5s 7g ^{3}G
	-	606232.0	-	100% $4d^{9}$ $5s^{2}$ 5d ^{3}G
	-	802191.0	-	44% $4d^{9}$ $5s^{2}$ 5g ^{1}H + 41% $4d^{9}$ $5s^{2}$ 5g ^{3}H
				+ 15% $4d^{9}$ $5s^{2}$ 5g ^{3}I
	-	802230.0	-	72% $4d^{9}$ $5s^{2}$ 5g ^{3}G + 15% $4d^{9}$ $5s^{2}$ 5g ^{1}H
				+ 13% $4d^{9}$ $5s^{2}$ 5g ^{3}H
	-	815145.0	-	85% $4d^{9}$ $5s^{2}$ 5g ^{3}I + 8% $4d^{9}$ $5s^{2}$ 5g ^{1}H
				+ 7% $4d^{9}$ $5s^{2}$ 5g ^{3}H
	-	815893.0	-	40% $4d^{9}$ $5s^{2}$ 5g ^{3}H + 33% $4d^{9}$ $5s^{2}$ 5g ^{1}H
				+ 28% $4d^{9}$ $5s^{2}$ 5g ^{3}G
6	-	801430.0	-	53% $4d^{9}$ $5s^{2}$ 5g ^{1}I + 47% $4d^{9}$ $5s^{2}$ 5g ^{3}I
	-	802200.0	-	85% $4d^{9}$ $5s^{2}$ 5g ^{3}H + 8% $4d^{9}$ $5s^{2}$ 5g ^{3}I
				+ 7% $4d^{9}$ $5s^{2}$ 5g ^{1}I
	-	815164.0	-	46% $4d^{9}$ $5s^{2}$ 5g ^{3}I + 39% $4d^{9}$ $5s^{2}$ 5g ^{1}I
				+ 15% $4d^{9}$ $5s^{2}$ 5g ^{3}H
7	-	801421.0	-	100% $4d^{9}$ $5s^{2}$ 5g ^{3}I

Table 6.3. Observed and fitted energy levels (in cm^{-1}) for odd parity configurations of I VI spectrum

J	E(obs)	E(LSF)	diff.	LS-composition.
0	85666.6	85710.0	-43.4	100% $4d^{10}$ 5s 5p ^3P
	335737.6	335708.0	29.6	99% $4d^{10}$ 5s 6p ^3P
	373009.0	373034.0	-25.0	99% $4d^{10}$ 5p 5d ^3P
	402785.0	402771.0	14.0	99% $4d^{10}$ 5p 6s ^3P
	435677.2	435588.0	89.2	100% $4d^{10}$ 5s 7p ^3P
	-	453529.0	-	100% $4d^{9}$ $^5s2$ 5p ^3P
	520663.6	520553.0	110.6	91% $4d^{10}$ 5p 6d ^3P + 9% $4d^{10}$ 4f 5d ^3P
	-	532208.0	-	91% $4d^{10}$ 4f 5d ^3P + 9% $4d^{10}$ 5p 6d ^3P
	-	586038.0	-	100% $4d^{9}$ ^4f $5s^2$ ^3P
1	89261.7	89209.0	52.7	97% $4d^{10}$ 5s 5p ^3P
	127423.8	127425.0	-1.2	95% $4d^{10}$ 5s 5p ^1P
	336197.2	336227.0	-29.8	80% $4d^{10}$ 5s 6p ^3P + 19% $4d^{10}$ 5s 6p ^1P
	341722.6	341715.0	7.6	78% $4d^{10}$ 5s 6p ^1P + 19% $4d^{10}$ 5s 6p ^3P
	361780.0	361793.0	-13.0	71% $4d^{10}$ 5p 5d ^3D + 20% $4d^{10}$ 5p 5d ^3P + 9% $4d^{10}$ 5p 5d ^1P
	373131.0	373114.0	17.0	75% $4d^{10}$ 5p 5d ^3P + 23% $4d^{10}$ 5p 5d ^3D
	386625.8	386625.0	0.8	86% $4d^{10}$ 5p 5d ^1P + 6% $4d^{10}$ 5p 5d ^3D
	404136.0	404151.0	-15.0	77% $4d^{10}$ 5p 6s ^3P + 20% $4d^{10}$ 5p 6s ^1P
	419603.0	419598.0	5.0	70% $4d^{10}$ 5p 6s ^1P + 21% $4d^{10}$ 5p 6s ^3P + 7% $4d^{10}$ 5s 7p ^1P
	436047.4	436152.0	-104.6	91% $4d^{10}$ 5s 7p ^3P + 7% $4d^{10}$ 5s 7p ^1P
	440218.9	440212.0	6.9	85% $4d^{10}$ 5s 7p ^1P + 7% $4d^{10}$ 5s 7p ^3P + 6% $4d^{10}$ 5p 6s ^1P
	443996.3	443794.0	202.3	78% $4d^{9}$ $^5s^2$ 5p ^3P + 20% $4d^{9}$ $5s^2$ 5p ^3D
	453180.0	453109.0	71.0	77% $4d^{9}$ $^5s^2$ 5p ^1P + 21% $4d^{9}$ $5s^2$ 5p ^3D
	460632.0	460902.0	-270.0	60% $4d^{9}$ $^5s^2$ 5p ^3D + 21% $4d^{9}$ $5s^2$ 5p ^1P + 19% $4d^{9}$ $5s^2$ 5p ^3P
	505522.2	505588.0	-65.8	66% $4d^{10}$ 5p 6d ^3D + 19% $4d^{10}$ 5p 6d ^1P + 13% $4d^{10}$ 5p 6d ^3P
	519545.6	519673.0	-127.4	57% $4d^{10}$ 5p 6d ^3P + 25% $4d^{10}$ 5p 6d ^3D + 9% $4d^{10}$ 5p 6d ^1P + 5% $4d^{10}$ 4f 5d ^3P
	522547.6	522465.0	82.6	61% $4d^{10}$ 5p 6d ^1P + 22% $4d^{10}$ 5p 6d ^3P + 9% $4d^{10}$ 4f 5d ^1P + 5% $4d^{10}$ 5p 6d ^3D
	-	528464.0	-	93% $4d^{10}$ 4f 5d ^3D
	-	531998.0	-	89% $4d^{10}$ 4f 5d ^3P + 7% $4d^{10}$ 5p 6d ^3P
	-	545717.0	-	85% $4d^{10}$ 4f 5d ^1P + 11% $4d^{10}$ 5p 6d ^1P
	-	588137.0	-	97% $4d^{9}$ 4f $5s^2$ ^3P
	-	610501.0	-	97% $4d^{9}$ 4f $5s^2$ ^3D
	716604.0	716604.0	0.0	99% $4d^{9}$ 4f $5s^2$ ^1P
2	99685.4	99694.0	-8.6	100% $4d^{10}$ 5s 5p ^3P
	276621.1	276509.0	112.1	99% $4d^{10}$ 4f 5s ^3F
	340462.4	340469.0	-6.6	98% $4d^{10}$ 5s 6p ^3P
	347472.0	347446.0	26.0	79% $4d^{10}$ 5p 5d ^3F + 18% $4d^{10}$ 5p 5d ^1D

	356797.0	356752.0	45.0	53% 4d^{10} 5p 5d ^{1}D + 21% 4d^{10} 5p 5d ^{3}P + 14% 4d^{10} 5p 5d ^{3}D
				+ 11% 4d^{10} 5p 5d ^{3}F
	366578.0	366575.0	3.0	41% 4d^{10} 5p 5d ^{3}D + 26% 4d^{10} 5p 5d ^{1}D + 24% 4d^{10} 5p 5d ^{3}P
				+ 8% 4d^{10} 5p 5d ^{3}F
	373476.0	373433.0	43.0	52% 4d^{10} 5p 5d ^{3}P + 44% 4d^{10} 5p 5d ^{3}D
	399216.1	399207.0	9.1	99% 4d^{10} 5s 5f ^{3}F
	417041.0	417044.0	-3.0	99% 4d^{10} 5p 6s ^{3}P
	-	429915.0	-	76% 4d^9 5s^2 5p ^{3}P + 18% 4d^9 5s^2 5p ^{3}D + 4% 4d^9 5s^2 5p ^{1}D
	438302.0	438298.0	4.0	99% 4d^{10} 5s 7p ^{3}P
	-	443746.0	-	82% 4d^9 5s^2 5p ^{3}F + 10% 4d^9 5s^2 5p ^{3}D + 8% 4d^9 5s^2 5p ^{3}P
	-	448296.0	-	68% 4d^9 5s^2 5p ^{1}D + 14% 4d^9 5s^2 5p ^{3}D + 12% 4d^9 5s^2 5p ^{3}P
				+ 6% 4d^9 5s^2 5p ^{3}F
	-	461531.0	-	99% 4d^{10} 5s 6f ^{3}F
	-	462631.0	-	58% 4d^9 5s^2 5p ^{3}D + 28% 4d^9 5s2 5p ^{1}D + 10% 4d^9 5s^2 5p ^{3}F
	503586.6	503507.0	79.6	67% 4d^{10} 5p 6d ^{3}F + 28% 4d^{10} 5p 6d ^{1}D
	505301.0	505258.0	43.0	43% 4d^{10} 5p 6d ^{3}D + 33% 4d^{10} 5p 6d ^{3}P + 16% 4d^{10} 5p 6d ^{1}D
				+ 6% 4d^{10} 5p 6d ^{3}F
	517247.5	516982.0	265.5	41% 4d^{10} 5p 6d ^{1}D + 28% 4d^{10} 5p 6d ^{3}D + 24% 4d^{10} 5p 6d ^{3}F
	-	518840.0	-	92% 4d^{10} 4f 5d ^{3}F + 5% 4d^{10} 4f 5d ^{1}D
	519605.4	519516.0	89.4	58% 4d^{10} 5p 6d ^{3}P + 23% 4d^{10} 5p 6d ^{3}D + 11% 4d^{10} 5p 6d ^{1}D
				+ 4% 4d^{10} 4f 5d ^{3}P
	-	522841.0	-	91% 4d^{10} 4f 5d ^{1}D
	-	528702.0	-	90% 4d^{10} 4f 5d ^{3}D + 5% 4d^{10} 4f 5d ^{3}P
	-	531692.0	-	88% 4d^{10} 4f 5d ^{3}P + 5% 4d^{10} 5p 6d ^{3}P + 4% 4d^{10} 4f 5d ^{3}D
	-	592209.0	-	88% 4d^9 4f 5s^2 ^{3}P + 7% 4d^9 4f 5s^2 ^{3}D + 4% 4d^9 4f 5s^2 ^{1}D
	-	605223.0	-	37% 4d^9 4f 5s^2 ^{1}D + 36% 4d^9 4f 5s^2 ^{3}F + 26% 4d^9 4f 5s^2 ^{3}D
	-	612899.0	-	50% 4d^9 4f 5s^2 ^{3}D + 38% 4d^9 4f 5s^2 ^{1}D + 11% 4d^9 4f 5s^2 ^{3}P
	-	618706.0	-	64% 4d^9 4f 5s^2 ^{3}F + 20% 4d^9 4f 5s^2 ^{1}D + 16% 4d^9 4f 5s^2 ^{3}D
3	276722.2	276732.0	-9.8	99% 4d^{10} 4f 5s ^{3}F
	281973.6	281974.0	0.4	97% 4d^{10} 4f 5s ^{1}F
	353652.0	353717.0	-65.0	90% 4d^{10} 5p 5d ^{3}F + 6% 4d^{10} 5p 5d ^{3}D
	371695.0	371738.0	-43.0	89% 4d^{10} 5p 5d ^{3}D + 7% 4d^{10} 5p 5d ^{3}F
	387975.0	387973.0	2.0	81% 4d^{10} 5p 5d ^{1}F + 11% 4d^{10} 5s 5f ^{1}F
	399339.1	399347.0	-7.9	99% 4d^{10} 5s 5f ^{3}F
	401413.6	401398.0	15.6	89% 4d^{10} 5s 5f ^{1}F + 10% 4d^{10} 5p 5d ^{1}F
	-	432441.0	-	54% 4d^9 5s^2 5p ^{3}F + 33% 4d^9 5s^2 5p ^{1}F + 14% 4d^9 5s^2 5p ^{3}D
	-	449808.0	-	75% 4d^9 5s^2 5p ^{3}D + 25% 4d^9 5s^2 5p ^{1}F
	-	459375.0	-	45% 4d^9 5s^2 5p ^{3}F + 42% 4d^9 5s^2 5p ^{1}F + 11% 4d^9 5s^2 5p ^{3}D
	-	461597.0	-	99% 4d^{10} 5s 6f ^{3}F
	-	462191.0	-	98% 4d^{10} 5s 6f ^{1}F
	505773.5	505836.0	-62.5	51% 4d^{10} 5p 6d ^{3}F + 28% 4d^{10} 5p 6d ^{3}D + 19% 4d^{10} 5p 6d ^{1}F
	517688.7	517873.0	-184.3	52% 4d^{10} 5p 6d ^{3}D + 32% 4d^{10} 5p 6d ^{3}F + 13% 4d^{10} 4f 5d ^{3}F
	-	519406.0	-	82% 4d^{10} 4f 5d ^{3}F + 9% 4d^{10} 5p 6d ^{3}D
	521010.9	521059.0	-48.1	59% 4d^{10} 5p 6d ^{1}F + 16% 4d^{10} 4f 5d ^{1}F + 13% 4d^{10} 5p 6d ^{3}F
				+ 6% 4d^{10} 5p 6d ^{3}D
	-	524332.0	-	99% 4d^{10} 4f 5d ^{3}G
	-	529032.0	-	91% 4d^{10} 4f 5d ^{3}D + 5% 4d^{10} 5p 6d ^{3}D

-	533897.0	-	78% $4d^{10}$ 4f 5d ^1F + 16% $4d^{10}$ 5p 6d ^1F
-	605697.0	-	53% $4d^9$ 4f $5s^2$ ^3D + 44% $4d^9$ 4f $5s^2$ ^3F
-	612480.0	-	33% $4d^9$ 4f $5s^2$ ^3D + 32% $4d^9$ 4f $5s^2$ ^3F + 19% $4d^9$ 4f $5s^2$ ^1F + 16% $4d^9$ 4f $5s^2$ ^3G
-	623151.0	-	57% $4d^9$ 4f $5s^2$ ^3G + 23% $4d^9$ 4f $5s^2$ ^3F + 11% $4d^9$ 4f $5s^2$ ^1F + 9% $4d^9$ 4f $5s^2$ ^3D
-	628996.0	-	70% $4d^9$ 4f $5s^2$ ^1F + 25% $4d^9$ 4f $5s^2$ ^3G + 4% $4d^9$ 4f $5s^2$ ^3D
276939.0	277041.0	-102.0	99% $4d^{10}$ 4f 5s ^3F
362500.0	362493.0	7.0	98% $4d^{10}$ 5p 5d ^3F
399513.3	399528.0	-14.7	99% $4d^{10}$ 5s 5f ^3F
-	443858.0	-	100% $4d^9$ $5s^2$ 5p ^3F
-	461662.0	-	100% $4d^{10}$ 5s 6f ^3F
-	516386.0	-	91% $4d^{10}$ 4f 5d ^1G + 6% $4d^{10}$ 4f 5d ^3H
-	518251.0	-	74% $4d^{10}$ 4f 5d ^3H + 14% $4d^{10}$ 5p 6d ^3F + 9% $4d^{10}$ 4f 5d ^3F
518094.8	518445.0	-350.2	54% $4d^{10}$ 5p 6d ^3F + 20% $4d^{10}$ 4f 5d ^3F + 20% $4d^{10}$ 4f 5d ^3H + 6% $4d^{10}$ 4f 5d ^1G
-	520562.0	-	67% $4d^{10}$ 4f 5d ^3F + 31% $4d^{10}$ 5p 6d ^3F
-	524990.0	-	99% $4d^{10}$ 4f 5d ^3G
-	606408.0	-	74% $4d^9$ 4f $5s^2$ ^3H + 13% $4d^9$ 4f $5s^2$ ^3G + 11% $4d^9$ 4f $5s^2$ ^1G
-	607476.0	-	86% $4d^9$ 4f $5s^2$ ^3F + 7% $4d^9$ 4f $5s^2$ ^1G + 5% $4d^9$ 4f $5s^2$ ^3G
-	616558.0	-	44% $4d^9$ 4f $5s^2$ ^1G + 33% $4d^9$ 4f $5s^2$ ^3G + 24% $4d^9$ 4f $5s^2$ ^3H
-	625213.0	-	49% $4d^9$ 4f $5s^2$ ^3G + 39% $4d^9$ 4f $5s^2$ ^1G + 12% $4d^9$ 4f $5s^2$ ^3F
-	519005.0	-	100% $4d^{10}$ 4f 5d ^3H
-	525720.0	-	100% $4d^{10}$ 4f 5d ^3G
-	538393.0	-	100% $4d^{10}$ 4f 5d ^1H
-	599824.0	-	74% $4d^9$ 4f $5s^2$ ^3H + 25% $4d^9$ 4f $5s^2$ ^1H
-	610037.0	-	47% $4d^9$ 4f $5s^2$ ^1H + 42% $4d^9$ 4f $5s^2$ ^3G + 11% $4d^9$ 4f $5s^2$ ^3H
-	618373.0	-	57% $4d^9$ 4f $5s^2$ ^3G + 28% $4d^9$ 4f $5s^2$ ^1H + 15% $4d^9$ 4f $5s^2$ ^3H
-	520018.0	-	100% $4d^{10}$ 4f 5d ^3H
-	597712.0	-	100% $4d^9$ 4f $5s^2$ ^3H

Table 6.4. Least Squares Fitted energy parameters (in cm^{-1}) for even parity configurations of I VI

Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$4d^{10}\,5s^2$	$E_{av}\,(4d^{10}\,5s^2)$	4853.1	268.0	5316.0	
$4d^{10}\,5s\,6s$	$E_{av}\,(4d^{10}\,5s\,6s)$	299084.6	189.0	293925.2	1.019
	$G^0(5s, 6s)$	3790.8	166.0	4760.9	0.796
$4d^{10}\,5s\,7s$	$E_{av}\,(4d^{10}\,5s\,7s)$	417174.4	184.0	412397.6	1.013
	$G^0(5s, 7s)$	1181.4	165.0	1619.8	0.729
$4d^{10}\,5s\,8s$	$E_{av}\,(4d^{10}\,5s\,8s)$	476953.1	184.0	471963.0	1.012
	$G^0(5s, 8s)$	554.9	168.0	777.4	0.714
$4d^{10}\,5s\,5d$	$E_{av}\,(4d^{10}\,5s\,5d)$	256646.6	127.0	251950.6	1.021
	ζ_{5d}	787.9	130.0	619.3	1.272
	$G^2(5s, 5d)$	28962.0	866.0	33502.2	0.864
$4d^{10}\,5s\,6d$	$E_{av}\,(4d^{10}\,5s\,6d)$	401101.4	149.0	395618.7	1.015
	ζ_{6d}	387.1	134.0	274.4	1.411
	$G^2(5s, 6d)$	5765.1	(fixed)	8238.9	0.700
$4d^{10}\,5s\,7d$	$E_{av}\,(4d^{10}\,5s\,7d)$	463368.8	(fixed)	463370.5	1.001
	ζ_{7d}	146.9	(fixed)	146.9	1.000
	$G^2(5s, 7d)$	2680.4	(fixed)	3573.9	0.750
$4d^{10}\,5s\,5g$	$E_{av}\,(4d^{10}\,5s\,5g)$	432996.8	119.0	434367.0	0.998
	ζ_{5g}	1.6	(fixed)	1.6	1.000
	$G^4(5s, 5g)$	2823.0	993.0	3321.6	0.850
$4d^{10}\,5s\,6g$	$E_{av}\,(4d^{10}\,5s\,6g)$	482669.4	117.0	483957.3	0.998
	ζ_{6g}	0.9	(fixed)	0.9	1.000
	$G^4(5s, 6g)$	2078.5	731.0	2445.7	0.850
$4d^{10}\,5s\,7g$	$E_{av}\,(4d^{10}\,5s\,7g)$	513416.8	134.0	513641.2	1.000
	ζ_{7g}	0.6	(fixed)	0.6	1.000
	$G^4(5s, 7g)$	1424.7	501.0	1675.9	0.850
$4d^{10}\,5p^2$	$E_{av}\,(4d^{10}\,5p^2)$	218824.2	144.0	216022.6	1.015
	$F^2(5p, 5p)$	45526.4	649.0	54938.2	0.829
	α_{5p}	-200.0	(fixed)		
	ζ_{5p}	9143.5	133.0	8366.2	1.093
$4d^{10}\,5d^2$	$E_{av}\,(4d^{10}\,5d^2)$	510285.3	118.0	513586.3	0.994
	$F^2(5d, 5d)$	35046.0	939.0	43946.2	0.797
	$F^4(5d, 5d)$	24454.2	655.0	30158.9	0.811
	α_{5d}	-322.3	-25.0		
	ζ_{5d}	692.3	66.0	651.3	1.063
$4d^{10}\,6s^2$	$E_{av}\,(4d^{10}\,6s^2)$	611008.5	236.0	614127.7	0.996
$4d^{10}\,5p\,6p$	$E_{av}\,(4d^{10}\,5p\,6p)$	449584.1	85.0	447118.5	1.007
	ζ_{5p}	8974.7	127.0	8998.1	0.997
	ζ_{6p}	3057.9	150.0	3013.5	1.015

	F^2(5p, 6p)	18257.1	581.0	22244.7	0.821
	G^0(5p, 6p)	4196.4	101.0	4796.3	0.875
	G^2(5p, 6p)	4882.5	(fixed)	6510.1	0.750
$4d^{10}\,4f\,5p$	E_{av} ($4d^{10}\,4f\,5p$)	384398.0	76.0	381528.5	1.009
	ζ_{4f}	141.5	(fixed)	141.4	1.001
	ζ_{5p}	8689.6	135.0	8128.3	1.069
	F^2(4f, 5p)	38089.1	872.0	48635.0	0.783
	G^2(4f, 5p)	28155.2	626.0	37948.5	0.742
	G^4(4f, 5p)	16330.0	(fixed)	27217.5	0.600
$4d^9\,5s^2\,5d$	E_{av} ($4d^9\,5s^2\,5d$)	613466.5	87.0	616102.9	0.996
	ζ_{4d}	5546.0	70.0	5424.1	1.022
	ζ_{5d}	746.1	(fixed)	679.1	1.099
	F^2(4d, 5d)	20375.1	479.0	23697.0	0.860
	F^4(4d, 5d)	9063.7	213.0	10542.5	0.860
	G^0(4d, 5d)	4646.9	(fixed)	5466.6	0.850
	G^2(4d, 5d)	5741.8	(fixed)	6754.4	0.850
	G^4(4d, 5d)	4753.6	(fixed)	5592.9	0.850
$4d^9\,5s^2\,6s$	E_{av} ($4d^9\,5s^2\,6s$)	658577.2	134.0	660875.8	0.997
	ζ_{4d}	5425.6	(fixed)	5425.7	1.000
	G^2(4d, 6s)	2691.1	(fixed)	3588.2	0.750
$4d^9\,5s^2\,5g$	E_{av} ($4d^9\,5s^2\,5g$)	807262.6	(fixed)	807265.4	1.001
	ζ_{4d}	5441.5	(fixed)	5441.6	1.000
	ζ_{5g}	1.6	(fixed)	1.6	1.000
	F^2(4d, 5g)	3727.0	(fixed)	4384.8	0.850
	F^4(4d, 5g)	757.6	(fixed)	891.3	0.850
	G^2(4d, 5g)	257.4	(fixed)	343.3	0.750
	G^4(4d, 5g)	168.1	(fixed)	224.2	0.750
	G^6(4d, 5g)	123.0	(fixed)	164.1	0.750
$4d^{10}\,5s^2$ -$4d^{10}\,5s\,6s$	R^0(5s, 5s; 5s, 6s)	2613.7	43.0	3670.6	0.712
$4d^{10}\,5s^2$ -$4d^{10}\,5s\,7s$	R^0(5s, 5s; 5s, 7s)	1288.7	21.0	1809.7	0.712
$4d^{10}\,5s^2$ -$4d^{10}\,5s\,8s$	R^0(5s, 5s; 5s, 8s)	820.7	13.0	1152.6	0.712
$4d^{10}\,5s^2$ -$4d^{10}\,5p^2$	R^1(5s, 5s; 5p, 5p)	50869.4	834.0	71441.0	0.712
$4d^{10}\,5s^2$ -$4d^{10}\,5d^2$	R^2(5s, 5s; 5d, 5d)	25390.1	417.0	35657.9	0.712
$4d^{10}\,5s^2$ -$4d^{10}\,5p\,6p$	R^1(5s, 5s; 5p, 6p)	3478.9	(fixed)	4638.5	0.750
$4d^{10}\,5s^2$ -$4d^9\,5s^2\,5d$	R^0(4d, 4d; 4d, 5d)	12641.9	207.0	17754.4	0.712
$4d^{10}\,5s^2$ -$4d^9\,5s^2\,5d$	R^2(4d, 4d; 4d, 5d)	1465.7	(fixed)	1954.3	0.750
	R^4(4d, 4d; 4d, 5d)	11079.9	(fixed)	14773.2	0.750
	R^2(4d, 4d; 4d, 6s	8506.0	(fixed)	11341.3	0.750
$4d^{10}\,5s^2$ -$4d^9\,5s^2\,5g$	R^2(4d, 4d; 4d, 5g)	-3806.1	(fixed)	-5074.7	0.750
	R^4(4d, 4d; 4d, 5g)	-3290.3	(fixed)	-4387.1	0.750
	R^0(5s, 6s; 5s, 7s)	-1900.1	(fixed)	-2533.4	0.750
$4d^{10}\,5s\,6s$ -$4d^{10}\,5s\,7s$	R^0(5s, 6s; 7s, 5s)	969.1	16.0	1361.1	0.712
	R^0(5s, 6s; 5s, 8s)	1938.4	32.0	2722.3	0.712
$4d^{10}\,5s\,6s$ -$4d^{10}\,5s\,8s$	R^0(5s, 6s; 8s, 5s)	656.5	11.0	922.1	0.712
	R^1(5s, 6s; 5p, 5p)	1313.1	22.0	1844.1	0.712
$4d^{10}\,5s\,6s$ -$4d^{10}\,5d^2$	R^2(5s, 6s; 5d, 5d)	-466.4	-8.0	-655.1	0.712

$4d^{10}$ 5s 6s -$4d^{10}$ 5p 6p	R^1(5s, 6s; 5p, 6p)	-8136.9	-133.0	-11427.4	0.712
$4d^{10}$ 5s 6s -$4d^{10}$ 5p 6p	R^1(5s, 6s; 6p, 5p)	752.9	12.0	1057.5	0.712
$4d^{10}$ 5s 6s -$4d^9$ $5s^2$ 5d	R^2(4d, 6s; 5s, 5d)	24118.7	396.0	33872.3	0.712
	R^0(4d, 6s; 5d, 5s)	3378.9	55.0	4745.4	0.712
$4d^{10}$ 5s 6s -$4d^9$ $5s^2$ 6s	R^2(4d, 4d; 4d, 5s)	1446.7	(fixed)	1929.0	0.750
	R^0(5s, 7s; 5s, 8s)	1966.0	(fixed)	2621.4	0.750
$4d^{10}$ 5s 7s -$4d^{10}$ 5s 8s	R^0(5s, 7s; 8s, 5s)	-6956.3	(fixed)	-9275.0	0.750
$4d^{10}$ 5s 7s -$4d^{10}$ $5p^2$	R^2(5s, 7s; 5d, 5d)	795.6	13.0	1117.4	0.712
$4d^{10}$ 5s 7s -$4d^{10}$ 5p 6p	R^1(5s, 7s; 5p, 6p)	-1262.1	-21.0	-1772.6	0.712
$4d^{10}$ 5s 7s -$4d^{10}$ 5p 6p	R^1(5s, 7s; 6p, 5p)	-4679.9	-77.0	-6572.3	0.712
$4d^{10}$ 5s 7s -$4d^9$ $5s^2$ 5d	R^2(4d, 7s; 5s, 5d)	1671.8	(fixed)	2229.1	0.750
$4d^{10}$ 5s 7s -$4d^9$ $5s^2$ 5d	R^0(4d, 7s; 5d, 5s)	4186.2	69.0	5879.0	0.712
	R^2(4d, 4d; 4d, 5s)	1568.9	26.0	2203.5	0.712
$4d^{10}$ 5s 8s -$4d^{10}$ $5p^2$	R^1(5s, 8s; 5p, 5p)	1148.2	(fixed)	1530.9	0.750
	R^2(5s, 8s; 5d, 5d)	1327.1	(fixed)	1769.4	0.750
$4d^{10}$ 5s 8s -$4d^{10}$ 5p 6p	R^1(5s, 8s; 5p, 6p)	-1165.4	-19.0	-1636.6	0.712
$4d^{10}$ 5s 8s -$4d^{10}$ 5p 6p	R^1(5s, 8s; 6p, 5p)	-3209.0	-53.0	-4506.7	0.712
$4d^{10}$ 5s 8s -$4d^9$ $5s^2$ 5d	R^2(4d, 8s; 5s, 5d)	1169.9	19.0	1569.0	0.750
$4d^{10}$ 5s 8s -$4d^9$ $5s^2$ 5d	R^0(4d, 8s; 5d, 5s)	1999.9	33.0	2808.6	0.712
	R^2(4d, 4d; 4d, 5s	931.1	15.0	1307.7	0.712
$4d^{10}$ 5s 5d -$4d^{10}$ 5s 6d	R^0(5s, 5d; 5s, 6d)	904.7	(fixed)	1206.3	0.750
	R^2(5s, 5d; 6d, 5s)	972.5	(fixed)	1296.6	0.750
$4d^{10}$ 5s 5d -$4d^{10}$ 5s 7d	R^0(5s, 5d; 5s, 7d)	1103.1	18.0	1549.1	0.712
	R^2(5s, 5d; 7d, 5s)	10970.9	180.0	15407.4	0.712
$4d^{10}$ 5s 5d -$4d^{10}$ $5p^2$	R^1(5s, 5d; 5p, 5p)	717.6	(fixed)	956.8	0.750
	R^2(5s, 5d; 5d, 5d)	7117.6	(fixed)	9490.1	0.750
$4d^{10}$ 5s 5d -$4d^{10}$ 5p 6p	R^1(5s, 5d; 5p, 6p)	41805.7	686.0	58712.0	0.712
$4d^{10}$ 5s 5d -$4d^{10}$ 5p 6p	R^1(5s, 5d; 6p, 5p)	26433.0	434.0	37122.5	0.712
$4d^{10}$ 5s 5d -$4d^{10}$ 4f 5p	R^3(5s, 5d; 4f, 5p)	-3556.6	-58.0	-4994.9	0.712
	R^1(5s, 5d; 5p, 4f)	8388.1	138.0	11780.3	0.712
$4d^{10}$ 5s 5d -$4d^9$ $5s^2$ 5d	R^2(4d, 4d; 4d, 5s)	-22305.3	-366.0	-29912.2	0.746
	R^2(4d, 5d; 5s, 5d)	-30373.0	-498.0	-40731.3	0.746
$4d^{10}$ 5s 5d -$4d^9$ $5s^2$ 5d	R^2(4d, 5d; 5d, 5s)	-6785.7	(fixed)	-9047.7	0.750
	R^2(4d, 5d; 5s, 6s)	-10676.5	(fixed)	-14235.4	0.750
	R^2(4d, 5d; 6s, 5s)	-4201.1	(fixed)	-5601.5	0.750
$4d^{10}$ 5s 5d -$4d^9$ $5s^2$ 5g	R^2(4d, 5d; 5s, 5g)	2428.2	(fixed)	3237.7	0.750
	R^2(4d, 5d; 5g, 5s)	-3227.7	(fixed)	-4303.5	0.750
$4d^{10}$ 5s 6d -$4d^{10}$ 5s 7d	R^0(5s, 6d; 5s, 7d)	-4896.2	(fixed)	-6528.2	0.750
	R^2(5s, 6d; 7d, 5s)	-2389.2	(fixed)	-3185.6	0.750
$4d^{10}$ 5s 6d -$4d^{10}$ $5p^2$	R^2(5s, 6d; 5d, 5d)	4025.9	(fixed)	5367.8	0.750
$4d^{10}$ 5s 6d -$4d^{10}$ 5p 6p	R^1(5s, 6d; 5p, 6p)	17175.4	282.0	24121.2	0.712
$4d^{10}$ 5s 6d -$4d^{10}$ 5p 6p	R^1(5s, 6d; 6p, 5p)	7113.9	117.0	9990.8	0.712
$4d^{10}$ 5s 6d -$4d^{10}$ 4f 5p	R^3(5s, 6d; 4f, 5p)	16627.8	273.0	23352.1	0.712
	R^1(5s, 6d; 5p, 4f)	5195.4	85.0	7296.4	0.712
$4d^{10}$ 5s 6d -$4d^9$ $5s^2$ 5d	R^2(4d, 6d; 5s, 5d)	-10165.3	-167.0	-13632.0	0.746
	R^2(4d, 6d; 5d, 5s)	-10578.4	-174.0	-14186.0	0.746

$4d^{10}$ 5s 6d -$4d^9$ $5s^2$ 6s	R^2(4d, 6d; 5s, 6s)	-3940.1	(fixed)	-5253.4	0.750
	R^2(4d, 6d; 6s, 5s)	-1874.9	(fixed)	-2499.8	0.750
$4d^{10}$ 5s 6d -$4d^9$ $5s^2$ 5g	R^2(4d, 6d; 5s, 5g)	-2021.9	(fixed)	-2695.9	0.750
	R^2(4d, 6d; 5g, 5s)	-2049.9	(fixed)	-2733.2	0.750
$4d^{10}$ 5s 7d -$4d^{10}$ $5p^2$	R^1(5s, 7d; 5p, 5p)	-123.3	(fixed)	-164.4	0.750
	R^2(5s, 7d; 5d, 5d)	-1249.3	(fixed)	-1665.8	0.750
$4d^{10}$ 5s 7d -$4d^{10}$ 5p 6p	R^1(5s, 7d; 5p, 6p)	10839.2	(fixed)	14452.3	0.750
$4d^{10}$ 5s 7d -$4d^{10}$ 5p 6p	R^1(5s, 7d; 6p, 5p)	3641.8	(fixed)	4855.	0.750
$4d^{10}$ 5s 7d -$4d^{10}$ 4f 5p	R^3(5s, 7d; 4f, 5p)	10466.8	(fixed)	13955.7	0.750
	R^1(5s, 7d; 5p, 4f)	3724.0	(fixed)	4965.3	0.750
$4d^{10}$ 5s 7d -$4d^9$ $5s^2$ 5d	R^2(4d, 7d; 5s, 5d)	-6263.3	(fixed)	-8351.1	0.750
	R^2(4d, 7d; 5d, 5s)	-6286.3	(fixed)	-8381.7	0.750
$4d^{10}$ 5s 7d -$4d^9$ $5s^2$ 6s	R^2(4d, 7d; 5s, 6s)	-2255.1	(fixed)	-3006.9	0.750
	R^2(4d, 7d; 6s, 5s)	-1109.4	(fixed)	-1479.	0.750
$4d^{10}$ 5s 7d -$4d^9$ $5s^2$ 5g	R^2(4d, 7d; 5s, 5g)	-1749.6	(fixed)	-2332.8	0.750
	R^2(4d, 7d; 5g, 5s)	-1448.5	(fixed)	-1931.3	0.750
$4d^{10}$ 5s 5g -$4d^{10}$ 5s 6g	R^0(5s, 5g; 5s, 6g)	-226.6	(fixed)	-302.	0.750
	R^4(5s, 5g; 6g, 5s)	-817.6	(fixed)	-1090.1	0.750
$4d^{10}$ 5s 5g -$4d^{10}$ 5s 7g	R^4(5s, 5g; 7g, 5s)	2111.8	35.0	2832.0	0.746
$4d^{10}$ 5s 5g -$4d^{10}$ $5d^2$	R^3(5s, 5g; 4f, 5p)	1731.6	28.0	2322.2	0.746
$4d^{10}$ 5s 5g -$4d^{10}$ 4f 5p	R^1(5s, 5g; 5p, 4f)	13198.4	217.0	17699.6	0.746
$4d^{10}$ 5s 5g -$4d^9$ $5s^2$ 5d	R^2(4d, 5g; 5s, 5d)	-8632.6	-142.0	-11576.7	0.746
	R^4(4d, 5g; 5d, 5s)	-15668.5	-257.0	-21012.2	0.746
$4d^{10}$ 5s 5g -$4d^9$ $5s^2$ 5g	R^2(4d, 4d; 4d, 5s)	-4732.5	(fixed)	-6310.0	0.750
	R^2(4d, 5g; 5s, 5g)	-1463.8	(fixed)	-1951.7	0.750
$4d^{10}$ 5s 5g -$4d^9$ $5s^2$ 5g	R^4(4d, 5g; 5g, 5s)	-6846.6	(fixed)	-9128.7	0.750
	R^0(5s, 6g; 5s, 7g)	-3264.8	(fixed)	-4353.0	0.750
	R^4(5s, 6g; 7g, 5s)	-519.3	(fixed)	-692.5	0.750
$4d^{10}$ 5s 6g -$4d^{10}$ $5d^2$	R^3(5s, 6g; 4f, 5p)	1506.5	25.0	2020.3	0.746
$4d^{10}$ 5s 6g -$4d^{10}$ 4f 5p	R^1(5s, 6g; 5p, 4f)	0.746	165.0	13519.0	0.746
$4d^{10}$ 5s 6g -$4d^9$ $5s^2$ 5d	R^2(4d, 6g; 5s, 5d)	-7450.1	-122.0	-9990.9	0.746
	R^4(4d, 6g; 5d, 5s)	-12571.1	-206.0	-16858.5	0.746
$4d^{10}$ 5s 6g -$4d^9$ $5s^2$ 5g	R^2(4d, 4d; 4d, 5s)	-3845.8	(fixed)	-5127.8	0.750
	R^2(4d, 6g; 5s, 5g)	-1331.2	(fixed)	-1774.9	0.750
$4d^{10}$ 5s 6g -$4d^9$ $5s^2$ 5g	R^2(5s, 7g; 5d, 5d)	-1859.3	(fixed)	-2479.0	0.750
	R^3(5s, 7g; 4f, 5p)	-470.4	(fixed)	-627.2	0.750
$4d^{10}$ 5s 7g -$4d^{10}$ 4f 5p	R^1(5s, 7g; 5p, 4f)	7789.5	128.0	10446.0	0.746
$4d^{10}$ 5s 7g -$4d^9$ $5s^2$ 5d	R^2(4d, 7g; 5s, 5d)	-6164.4	-101.0	-8266.7	0.746
	R^4(4d, 7g; 5d, 5s)	-10074.2	-165.0	-13509.9	0.746
$4d^{10}$ 5s 7g -$4d^9$ $5s^2$ 5g	R^2(4d, 4d; 4d, 5s)	-3087.0	(fixed)	-4116.0	0.750
	R^2(4d, 7g; 5s, 5g)	-1134.4	(fixed)	-1512.5	0.750
$4d^{10}$ 5s 7g -$4d^9$ $5s^2$ 5g	R^1(5p, 5p; 5d, 5d)	-1300.4	(fixed)	-1733.8	0.750
	R^3(5p, 5p; 5d, 5d)	-400.1	(fixed)	-533.4	0.750
$4d^{10}$ $5p^2$ -$4d^{10}$ $6s^2$	R^1(5p, 5p; 6s, 6s)	38131.2	626.0	53551.5	0.712
	R^0(5p, 5p; 5p, 6p)	24327.8	399.0	34166.0	0.712
$4d^{10}$ $5p^2$ -$4d^{10}$ 5p 6p	R^2(5p, 5p; 5p, 6p)	6158.2	101.0	8258.4	0.746

$4d^{10}\,5p^2$ $-4d^{10}\,4f\,5p$	R^2(5p, 5p; 4f, 5p)	1325.7	22.0	1861.9	0.712
	R^2(5d, 5d; 6s, 6s)	6097.8	100.0	8563.8	0.712
$4d^{10}\,5d^2$ $-4d^{10}\,5p\,6p$	R^1(5d, 5d; 5p, 6p)	-32646.1	-536.0	-43779.8	0.746
$4d^{10}\,5d^2$ $-4d^{10}\,5p\,6p$	R^3(5d, 5d; 5p, 6p)	12916.0	212.0	17320.7	0.746
$4d^{10}\,5d^2$ $-4d^{10}\,4f\,5p$	R^1(5d, 5d; 4f, 5p)	-5636.4	-92.0	-7915.9	0.712
	R^3(5d, 5d; 4f, 5p)	-2341.9	-38.0	-3288.9	0.712
$4d^{10}\,5d^2$ $-4d^9\,5s^2\,5d$	R^2(4d, 5d; 5s, 5s)	-28961.4	-475.0	-38838.4	0.746
	R^1(6s, 6s; 5p, 6p)	-19569.6	-321.0	-26243.7	0.746
$4d^{10}\,5p\,6p$ $-4d^{10}\,4f\,5p$	R^2(5p, 6p; 4f, 5p)	-11479.3	(fixed)	-15305.8	0.750
$4d^{10}\,5p\,6p$ $-4d^{10}\,4f\,5p$	R^2(5p, 6p; 5p, 4f)	-6391.5	-105.0	-8571.1	0.746
$4d^9$ 5s2 5d $-4d^9\,5s^2\,6s$	R^2(4d, 5d; 4d, 6s)	-4576.0	-75.0	-6136.5	0.746
	R^2(4d, 5d; 6s, 4d)	-4721.4	-77.0	-6331.6	0.746
$4d^9\,5s^2\,5d$ $-4d^9\,5s^2\,5g$	R^2(4d, 5d; 4d, 5g)	1817.3	(fixed)	2423.0	0.750
	R^4(4d, 5d; 4d, 5g)	2016.6	(fixed)	2688.9	0.750
$4d^9\,5s^2\,5d$ $-4d^9\,5s^2\,5g$	R^2(4d, 5d; 5g, 4d)	2016.6	(fixed)	6496.3	0.750
	R^4(4d, 5d; 5g, 4d)	1342.1	(fixed)	1789.4	0.750
	R^4(4d, 6s; 4d, 5g)	227.2	(fixed)	302.9	0.750
	R^2(4d, 6s; 5g, 4d)	234.4	(fixed)	312.6	0.750
	σ	232			

Table 6.5. Least Squares Fitted energy parameters (in cm^{-1}) for odd parity configurations of I VI

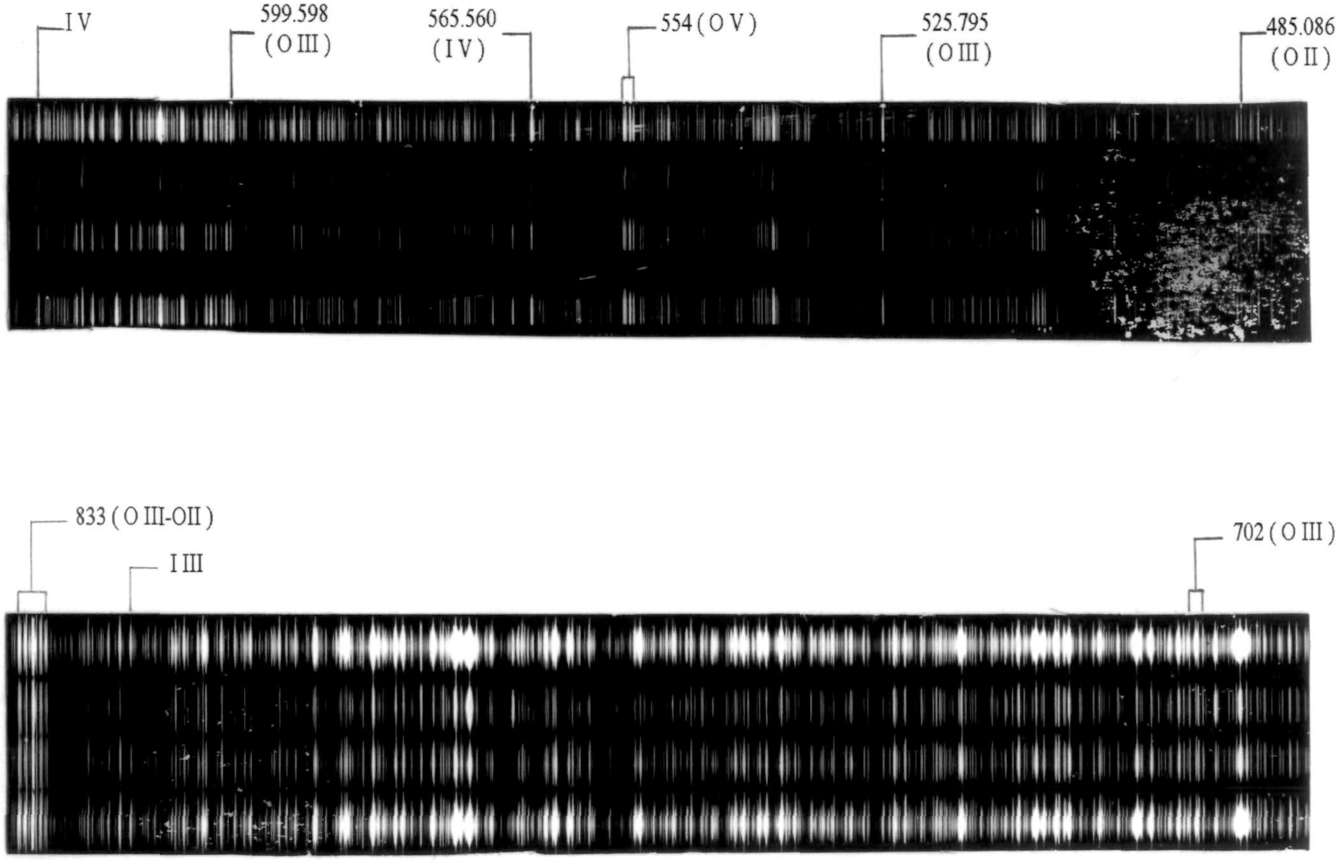
Configuration	Parameter	LSF	Accuracy	HFR	LSF/HFR
$4d^{10}$ 5s 5p	E_{av} ($4d^{10}$ 5s 5p)	105150.1	160.0	100282.7	1.056
	ζ_{5p}	9349.5	129.0	8429.4	1.109
	G^1(5s, 5p)	56852.4	580.0	71430.3	0.796
$4d^{10}$ 5s 6p	E_{av} ($4d^{10}$ 5s 6p)	340597.2	143.0	335559.5	1.017
	ζ_{6p}	3217.6	114.0	3010.9	1.069
	G^1(5s, 6p)	5651.4	442.0	7989.3	0.707
$4d^{10}$ 5s 7p	E_{av} ($4d^{10}$ 5s 7p)	437641.0	100.0	432633.1	1.013
	ζ_{7p}	1744.7	126.0	1478.9	1.180
	G^1(5s, 7p)	2274.5	415.0	2934.9	0.775
$4d^{10}$ 4f 5s	E_{av} ($4d^{10}$ 4f 5s)	279275.7	133.0	275127.1	1.017
	ζ_{4f}	134.2	(fixed)	134.3	0.999
	G^3(4f, 5s)	26403.1	1084.0	36075.7	0.732
$4d^{10}$ 5s 5f	E_{av} ($4d^{10}$ 5s 5f)	399443.7	89.0	395574.8	1.011
	ζ_{5f}	61.6	(fixed)	61.6	1.000
	G^3(5s, 5f)	3079.6	(fixed)	4106.2	0.750
$4d^{10}$ 5s 6f	E_{av} ($4d^{10}$ 5s 6f)	461616.5	(fixed)	461614.8	1.001
	ζ_{6f}	31.9	(fixed)	32.0	0.997
	G^3(5s, 6f)	1305.2	(fixed)	1740.3	0.750
$4d^{10}$ 5p 5d	E_{av} ($4d^{10}$ 5p 5d)	367450.3	57.0	360799.1	1.020
	ζ_{5p}	9232.1	143.0	8564.1	1.078
	ζ_{5d}	768.7	91.0	636.1	1.208
	F^2(5p, 5d)	33757.5	697.0	45013.3	0.750
	G^1(5p, 5d)	37828.3	286.0	52260.4	0.724
	G^3(5p, 5d)	20612.1	672.0	33350.3	0.618
$4d^{10}$ 5p 6d	E_{av} ($4d^{10}$ 5p 6d)	515036.5	56.0	507419.1	1.016
	ζ_{5p}	9569.2	73.0	8998.7	1.063
	ζ_{6d}	276.7	(fixed)	276.7	1.000
	F^2(5p, 6d)	14729.0	553.0	16798.0	0.877
	G^1(5p, 6d)	6876.6	316.0	9094.1	0.756
	G^3(5p, 6d)	5202.0	521.0	6858.9	0.758
$4d^{10}$ 4f 5d	E_{av} ($4d^{10}$ 4f 5d)	524397.4	(fixed)	524395.5	1.001
	ζ_{4f}	152.0	(fixed)	152.0	1.000
	ζ_{5d}	604.2	(fixed)	604.2	1.000
	F^2(4f, 5d)	30598.9	(fixed)	35998.7	0.850
	F^4(4f, 5d)	18159.4	(fixed)	21364.0	0.850
	G^1(4f, 5d)	21220.6	(fixed)	28294.2	0.750
	G^3(4f, 5d)	15554.1	(fixed)	20738.9	0.750
	G^5(4f, 5d)	11570.0	(fixed)	15426.7	0.750
$4d^{10}$ 5p 6s	E_{av} ($4d^{10}$ 5p 6s)	413091.7	83.0	406504.7	1.018
	ζ_{5p}	9589.4	115.0	8852.2	1.083

	G^1(5p, 6s)	5723.5	415.0	7249.6	0.789
$4d^9\,4f\,5s^2$	E_{av} ($4d^9\,4f\,5s^2$)	612326.1	148.0	623499.2	0.983
	ζ_{4d}	5336.5	(fixed)	5336.6	1.000
	ζ_{4f}	181.6	(fixed)	181.7	0.999
	F^2(4d, 4f)	59189.2	(fixed)	69634.4	0.850
	F^4(4d, 4f)	36240.5	(fixed)	42636.0	0.850
	G^1(4d, 4f)	60123.5	(fixed)	80164.8	0.750
	G^3(4d, 4f)	36435.5	(fixed)	48580.8	0.750
	G^5(4d, 4f)	25411.7	(fixed)	33882.3	0.750
$4d^9$ 5s2 5p	E_{av} ($4d^9\,5s^2\,5p$)	447202.4	108.0	450750.8	0.993
	ζ_{4d}	5398.5	(fixed)	5398. 6	1.000
	ζ_{5p}	9214.2	(fixed)	9214.3	1.000
	F^2(4d, 5p)	26880.0	(fixed)	38400.0	0.700
	G^1(4d, 5p)	10282.9	197.0	11691.5	0.880
	G^3(4d, 5p)	9906.0	190.0	11262.9	0.880
$4d^{10}$5s 5p -$4d^{10}$ 5s 6p	R^0(5s, 5p; 5s, 6p)	2160.9	121.0	3104.0	0.696
	R^1(5s, 5p; 6p, 5s)	12688.5	710.0	18226.6	0.696
$4d^{10}$5s 5p -$4d^{10}$ 5s 7p	R^0(5s, 5p; 5s, 7p)	1117.2	63.0	1604.8	0.696
	R^1(5s, 5p; 7p, 5s)	6511.7	364.0	9353.8	0.696
$4d^{10}$5s 5p -$4d^{10}$ 5p 5d	R^1(5s, 5p; 5p, 5d)	41441.8	2320.0	59529.3	0.696
	R^2(5s, 5p; 5d, 5p)	30193.2	1690.0	43371.2	0.696
$4d^{10}$5s 5p -$4d^{10}$ 5p 6d	R^1(5s, 5p; 5p, 6d)	16872.1	944.0	24236.0	0.696
	R^2(5s, 5p; 6d, 5p)	14231.6	797.0	20443.1	0.696
$4d^{10}$5s 5p -$4d^{10}$ 4f 5d	R^3(5s, 5p; 4f, 5d)	-22005.9	(fixed)	-29341.2	0.750
	R^2(5s, 5p; 5d, 4f)	-24877.1	(fixed)	-33169.5	0.750
$4d^{10}$5s 5p -$4d^{10}$ 5p 6s	R^1(5s, 5p; 5p, 6s)	285.8	16.0	410.6	0.696
	R^0(5s, 5p; 6s, 5p)	104.1	6.0	149.5	0.696
$4d^{10}$5s 5p -$4d^9$ 4f 5s2	R^1(4d, 5p; 4f, 5s)	42448.3	(fixed)	56597.7	0.750
	R^2(4d, 5p; 5s, 4f)	15966.8	(fixed)	21289.1	0.750
$4d^{10}$5s 5p -$4d^9$ 5s2 5p	R^2(4d, 4d; 4d, 5s)	-6862.6	(fixed)	-9150.2	0.750
	R^2(4d, 5p; 5s, 5p)	-16352.7	(fixed)	-21803.7	0.750
	R^1(4d, 5p; 5p, 5s)	-14645.3	(fixed)	-19527.1	0.750
$4d^{10}$5s 6p -$4d^{10}$ 5s 7p	R^1(5s, 6p; 7p, 5s)	3300.5	185.0	4741.1	0.696
$4d^{10}$5s 6p -$4d^{10}$ 5p 5d	R^1(5s, 6p; 5p, 5d)	-2756.0	-154.0	-3958.9	0.696
	R^2(5s, 6p; 5d, 5p)	4128.5	231.0	5930.4	0.696
$4d^{10}$5s 6p -$4d^{10}$ 5p 6d	R^1(5s, 6p; 5p, 6d)	16684.3	934.0	23966.3	0.696
	R^2(5s, 6p; 6d, 5p)	3669.3	205.0	5270.8	0.696
$4d^{10}$5s 6p -$4d^{10}$ 4f 5d	R^3(5s, 6p; 4f, 5d)	-597.8	(fixed)	-797.0	0.750
	R^2(5s, 6p; 5d, 4f)	-3134.1	(fixed)	-4178.8	0.750
$4d^{10}$5s 6p -$4d^{10}$ 5p 6s	R^1(5s, 6p; 5p, 6s)	23638.3	1323.0	33955.5	0.696
	R^0(5s, 6p; 6s, 5p)	3389.9	190.0	4869.4	0.696
$4d^{10}$5s 6p -$4d^9$ 4f 5s2	R^1(4d, 6p; 4f, 5s)	15397.1	(fixed)	20529.4	0.750
	R^2(4d, 6p; 5s, 4f	5694.5	(fixed)	7592.7	0.750
$4d^{10}$5s 6p -$4d^9$ 5s2 5p	R^2(4d, 6p; 5s, 5p)	-4483.2	(fixed)	-5977.6	0.750
	R^1(4d, 6p; 5p, 5s)	-3750.0	(fixed)	-5000.1	0.750
$4d^{10}$5s 7p -$4d^{10}$ 5p 5d	R^1(5s, 7p; 5p, 5d)	-2121.5	-119.0	-3047.5	0.696

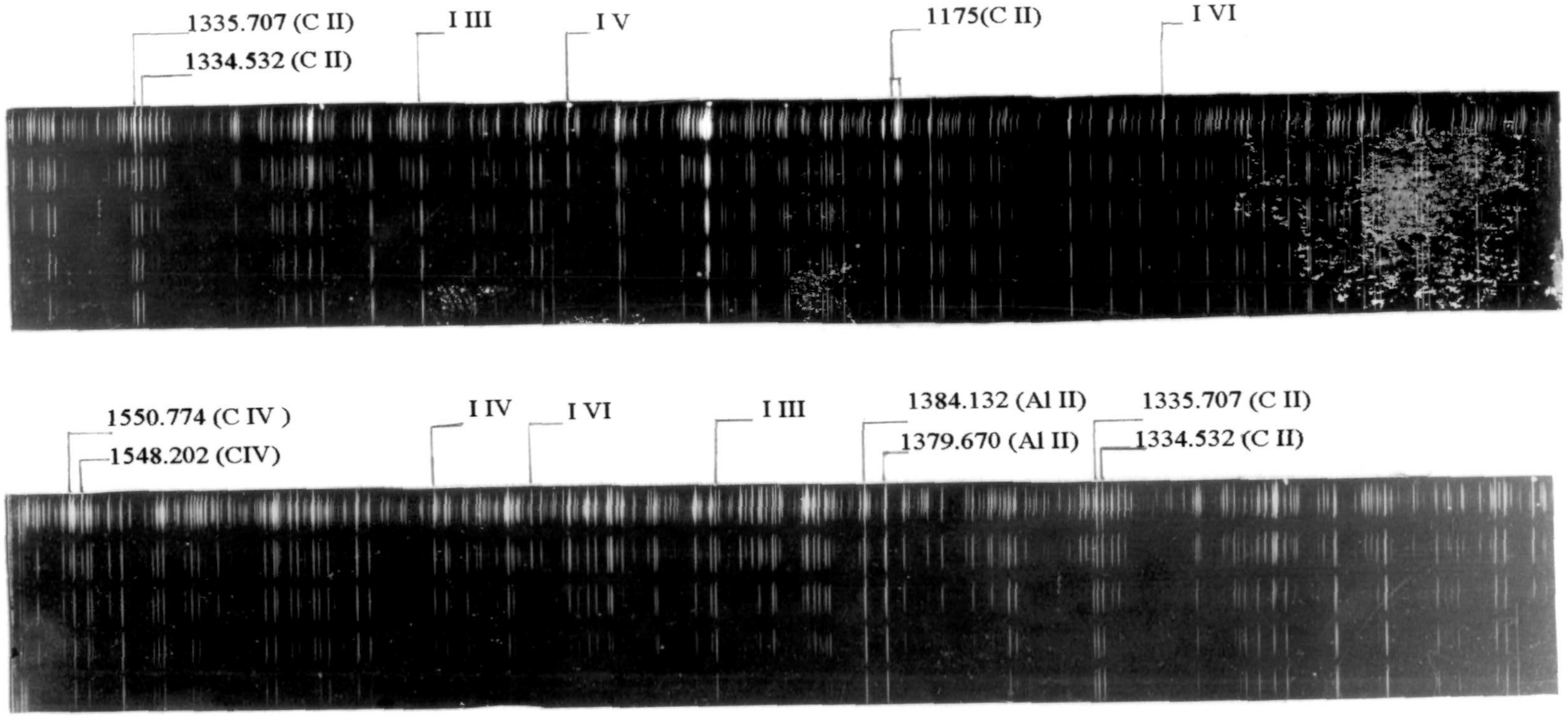
	R^2(5s, 7p; 5d, 5p)	1307.3	73.0	1877.9	0.696
$4d^{10}5s\ 7p\ \text{-}4d^{10}\ 5p\ 6d$	R^1(5s, 7p; 5p, 6d)	512.7	29.0	736.4	0.696
	R^2(5s, 7p; 6d, 5p)	1708.3	96.0	2453.8	0.696
$4d^{10}5s\ 7p\ \text{-}4d^{10}\ 4f\ 5d$	R^3(5s, 7p; 4f, 5d)	555.0	31.0	797.3	0.696
	R^2(5s, 7p; 5d, 4f)	-1240.8	(fixed)	-1654.3	0.750
$4d^{10}5s\ 7p\ \text{-}4d^{10}\ 5p\ 6s$	R^1(5s, 7p; 5p, 6s)	10647.1	596.0	15294.1	0.696
	R^0(5s, 7p; 6s, 5p)	2014.0	113.0	2893.1	0.696
$4d^{10}5s\ 7p\ \text{-}4d^9\ 4f\ 5s2$	R^1(4d, 7p; 4f, 5s)	9205.5	(fixed)	12273.9	0.750
	R^2(4d, 7p; 5s, 4f)	3462.7	(fixed)	4616.9	0.750
$4d^{10}5s\ 7p\ \text{-}4d^9\ 5s2\ 5p$	R^2(4d, 7p; 5s, 5p)	-2296.3	(fixed)	-3061.7	0.750
	R^1(4d, 7p; 5p, 5s)	-1861.8	(fixed)	-2482.4	0.750
$4d^{10}4f\ 5s\ \text{-}4d^{10}\ 5s\ 5f$	R^3(4f, 5s; 5s, 5f)	4591.4	257.0	6595.4	0.696
	R^0(4f, 5s; 5f, 5s)	334.0	19.0	479.7	0.696
$4d^{10}4f\ 5s\ \text{-}4d^{10}\ 5s\ 6f$	R^3(4f, 5s; 5s, 6f)	365.4	(fixed)	487.1	0.750
	R^0(4f, 5s; 6f, 5s)	31.6	(fixed)	42.1	0.751
$4d^{10}4f\ 5s\ \text{-}4d^{10}\ 5p\ 5d$	R^2(4f, 5s; 5p, 5d)	-24288.7	-1360.0	-34889.6	0.696
	R^1(4f, 5s; 5d, 5p)	-29439.9	-1648.0	-42289.2	0.696
$4d^{10}4f\ 5s\ \text{-}4d^{10}\ 5p\ 6d$	R^2(4f, 5s; 5p, 6d)	-11229.5	-629.0	-16130.6	0.696
	R^1(4f, 5s; 6d, 5p)	-9844.8	-551.0	-14141.5	0.696
$4d^{10}4f\ 5s\ \text{-}4d^{10}\ 4f\ 5d$	R^2(4f, 5s; 4f, 5d)	27401.2	(fixed)	36534.9	0.750
	R^3(4f, 5s; 5d, 4f)	18419.5	(fixed)	24559.4	0.750
$4d^{10}4f\ 5s\ \text{-}4d^9\ 4f\ 5s2$	R^2(4d, 4d; 4d, 5s)	-6897.9	(fixed)	-9197.2	0.750
	R^3(4d, 4f; 4f, 5s)	-15769.5	(fixed)	-21026.0	0.750
	R^2(4d, 4f; 5s, 4f)	-15031.3	(fixed)	-20041.7	0.750
$4d^{10}4f\ 5s\ \text{-}4d^9\ 5s2\ 5p$	R^2(4d, 4f; 5s, 5p)	16906.3	(fixed)	22541.7	0.750
	R^3(4d, 4f; 5p, 5s)	13394.8	(fixed)	17859.7	0.750
$4d^{10}5s\ 5f\ \text{-}4d^{10}\ 5s\ 6f$	R^3(5s, 5f; 6f, 5s)	1718.0	(fixed)	2290.7	0.750
$4d^{10}5s\ 5f\ \text{-}4d^{10}\ 5p\ 5d$	R^1(5s, 5f; 5p, 5d)	10657.2	597.0	15308.7	0.696
	R^2(5s, 5f; 5d, 5p)	803.6	45.0	1154.4	0.696
$4d^{10}5s\ 5f\ \text{-}4d^{10}\ 5p\ 6d$	R^1(5s, 5f; 5p, 6d)	-11284.2	-632.0	-16209.2	0.696
	R^2(5s, 5f; 6d, 5p)	-964.2	-54.0	-1385.0	0.696
$4d^{10}5s\ 5f\ \text{-}4d^{10}\ 4f\ 5d$	R^3(5s, 5f; 4f, 5d)	-2188.2	(fixed)	-2917.7	0.750
	R^2(5s, 5f; 5d, 4f)	3306.7	(fixed)	4408.9	0.750
$4d^{10}5s\ 5f\ \text{-}4d^9\ 4f\ 5s2$	R^3(4d, 5f; 4f, 5s)	-4042.2	(fixed)	-5389.6	0.750
	R^2(4d, 5f; 5s, 4f)	-3531.4	(fixed)	-4708.5	0.750
$4d^{10}5s\ 5f\ \text{-}4d^9\ 5s2\ 5p$	R^2(4d, 5f; 5s, 5p)	3495.7	(fixed)	4660.9	0.750
	R^3(4d, 5f; 5p, 5s)	3937.0	(fixed)	5249.3	0.750
$4d^{10}5s\ 6f\ \text{-}4d^{10}\ 5p\ 5d$	R^1(5s, 6f; 5p, 5d)	10731.7	(fixed)	14308.9	0.750
	R^2(5s, 6f; 5d, 5p)	3878.7	(fixed)	5171.6	0.750
$4d^{10}5s\ 6f\ \text{-}4d^{10}\ 5p\ 6d$	R^1(5s, 6f; 5p, 6d)	2794.1	(fixed)	3725.5	0.750
	R^2(5s, 6f; 6d, 5p)	939.4	(fixed)	1252.5	0.750
$4d^{10}5s\ 6f\ \text{-}4d^{10}\ 4f\ 5d$	R^3(5s, 6f; 4f, 5d	-3660.1	(fixed)	-4880.1	0.750
	R^2(5s, 6f; 5d, 4f)	-93.6	(fixed)	-124.8	0.750
$4d^{10}\ 5s\ 6f\ \text{-}4d^9\ 4f\ 5s^2$	R^3(4d, 6f; 4f, 5s)	-1046.0	(fixed)	-1394.6	0.750
	R^2(4d, 6f; 5s, 4f)	-1012.2	(fixed)	-1349.6	0.750
$4d^{10}\ 5s\ 6f\ \text{-}4d^9\ 5s^2\ 5p$	R^2(4d, 6f; 5s, 5p)	701.6	(fixed)	935.4	0.750

	R^3(4d, 6f; 5p, 5s)	1488.3	(fixed)	1984.5	0.750
$4d^{10}$ 5p 5d -$4d^{10}$ 5p 6d	R^0(5p, 5d; 5p, 6d)	1286.4	72.0	1847.9	0.696
	R^2(5p, 5d; 5p, 6d)	8743.6	489.0	12559.7	0.696
	R^1(5p, 5d; 6d, 5p)	13316.0	745.0	19127.9	0.696
	R^3(5p, 5d; 6d, 5p)	8937.9	500.0	12839.0	0.696
$4d^{10}$ 5p 5d -$4d^{10}$ 4f 5d	R^2(5p, 5d; 4f, 5d)	-26117.6	(fixed)	-34823.5	0.750
	R^4(5p, 5d; 4f, 5d)	-17162.4	(fixed)	-22883.2	0.750
	R^1(5p, 5d; 5d, 4f)	-27084.3	(fixed)	-36112.4	0.750
	R^3(5p, 5d; 5d, 4f)	-18394.9	(fixed)	-24526.6	0.750
$4d^{10}$ 5p 5d -$4d^{10}$ 5p 6s	R^2(5p, 5d; 5p, 6s)	-8439.0	-472.0	-12122.3	0.696
	R^1(5p, 5d; 6s, 5p)	-2780.5	-156.0	-3994.1	0.696
$4d^{10}$ 5p 5d -$4d^9$ $5s^2$ 5p	R^2(4d, 5d; 5s, 5s)	-11384.0	(fixed)	-15178.7	0.750
$4d^{10}$ 5p 6d -$4d^{10}$ 4f 5d	R^2(5p, 6d; 4f, 5d)	-6743.5	(fixed)	-8991.3	0.750
	R^4(5p, 6d; 4f, 5d)	-5518.2	(fixed)	-7357.6	0.750
	R^1(5p, 6d; 5d, 4f)	-8288.8	(fixed)	-11051.7	0.750
	R^3(5p, 6d; 5d, 4f)	-6527.6	(fixed)	-8703.4	0.750
$4d^{10}$ 5p 6d -$4d^{10}$ 5p 6s	R^2(5p, 6d; 5p, 6s)	7567.3	424.0	10870.1	0.696
	R^1(5p, 6d; 6s, 5p)	1452.2	81.0	2086.0	0.696
$4d^{10}$ 5p 6d -$4d^9$ $5s^2$ 5p	R^2(4d, 6d; 5s, 5s)	-6118.7	(fixed)	-8158.2	0.750
$4d^{10}$ 4f 5d -$4d^{10}$ 5p 6s	R^2(4f, 5d; 5p, 6s)	7995.4	(fixed)	10660.5	0.750
	R^3(4f, 5d; 6s, 5p)	1666.7	(fixed)	2222.3	0.750
$4d^{10}$ 4f 5d -$4d^9$ 4f $5s^2$	R^2(4d, 5d; 5s, 5s)	-11177.4	(fixed)	-14903.1	0.750
$4d^9$ 4f 5s2 -$4d^9$ $5s^2$ 5p	R^2(4d, 4f; 4d, 5p)	-13126.6	(fixed)	-17502.1	0.750
	R^4(4d, 4f; 4d, 5p)	-5056.3	(fixed)	-6741.7	0.750
	R^1(4d, 4f; 5p, 4d)	-4616.6	(fixed)	-6155.5	0.750
	R^3(4d, 4f; 5p, 4d)	-2395.7	(fixed)	-3194.3	0.750
	σ	146			

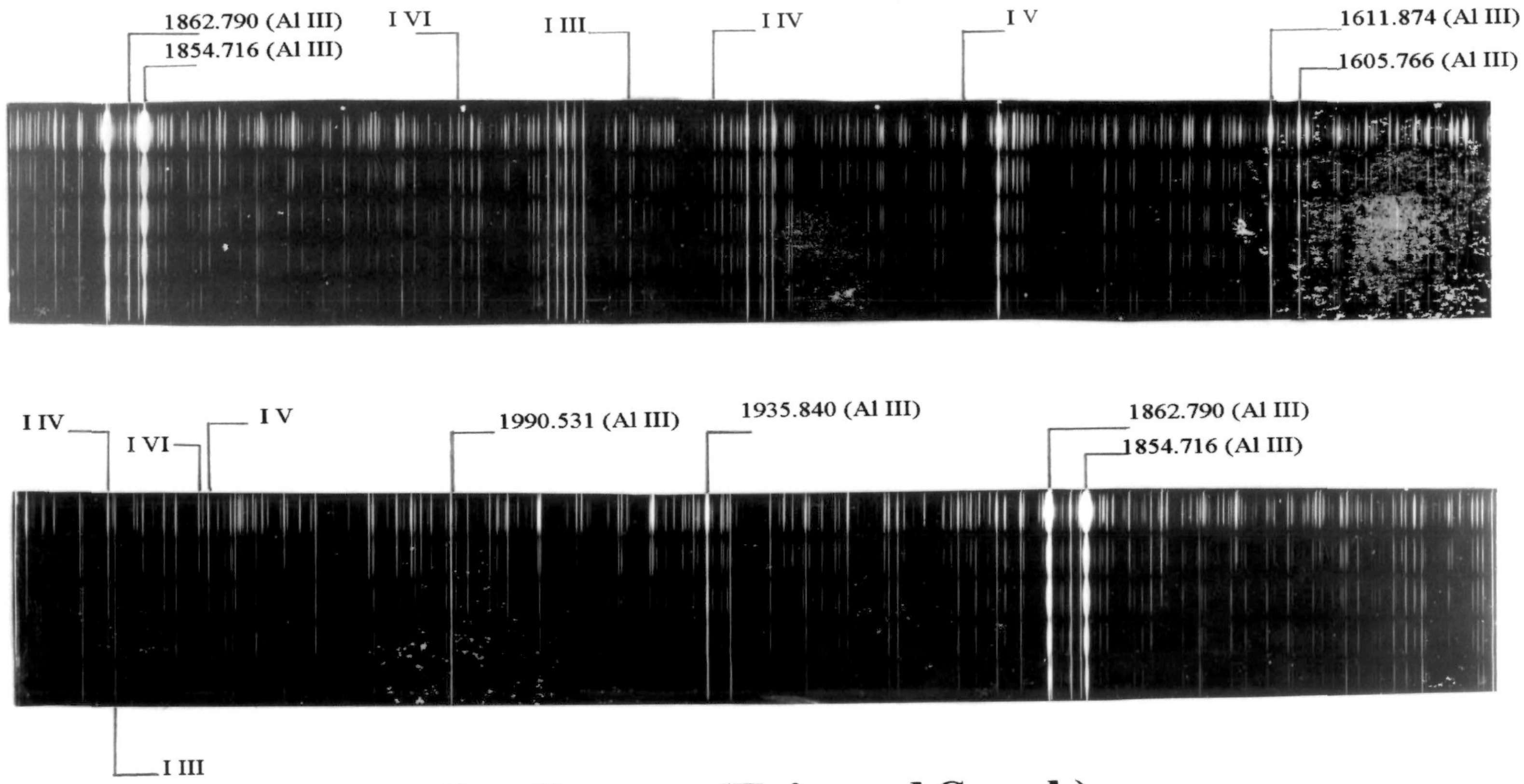
APPENDIX



Iodine Spectra (Tigerred Spark)



Iodine Spectra (Trigerred Spark)



Iodine Spectra (Trigrred Spark)

List of publications and conference presentations:

1. A. Tauheed, Y. N. Joshi , **Anjum Naz** "Extended Analysis of the fourth Spectrum of Iodine: I IV" Physica Scripta, **69**, 283-288 (2004).
2. A. Tauheed, Y. N. Joshi, **Anjum Naz** "Extended Analysis of Doubly ionized Iodine Spectrum: I III" Physica Scripta, **69**, 289-296 (2004).

Conferences presentations:

3. A.Tauheed and **Anjum Naz** "Experimental and theoretical interpretation of singly ionized iodine: (I II)" National symposium on atomic physics at the frontiers (APF 2000) Physics Department University of Roorkee, April 13-15 (2000).
4. A. Tauheed and **Anjum Naz**, " Spectral Investigation of Triply Ionized Iodine: I IV" International Conference on Current Developments in Atomic, Molecular, and Chemical Physics with Applications (CDAMCP) Department of Physics and Astrophysics, University of Delhi March 20 – 22, 2002.
5. **Anjum Naz**, A.Tauheed, K. Rahimuullah and Y.N. Joshi "The $5s^2 5p^3$, 5s25p2(5d +6d+7d+6s+7s+8s) and $5s5p^4$ configurations of doubly ionized iodine: (I III), National Symposium on Atomic, Molecular Structure, Interactions and Laser Spectroscopy (NSAMSILS-2004), Department of Physics B.H.U. Vrarnasi,March 14-14 (2004).
6. **Anjum Naz**, A. Tauheed and K. Rahimllah, "New Spectral Identificaions in I VI " 2nd International Conference on Current Developments in Atomic, Moleculer & Optical Physics with Applications, Delhi University, Delhi, March 21-23, 2006.

7. **Anjum Naz** and A. Tauheed, "Highly Excited Configurations of Four-Times Ionized Iodine: I V" IAEA International Workshop on "Challenges in Plasma Spectroscopy for Future Fusion Research Machines", B.M. Birla Auditorium, Jaipur 20-22 February, 2008.